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OSSEOUS DEVELOPMENT AS AN INDEX OF METABOLISM¹

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THERE was a time when clinical medicine paved the way for biochemical research: of late years the reverse has been true. The laboratory, long looked upon as merely an adjunct in the elucidation of disease, now assumes an importance second to none. The change came about through the gradual recognition that a living organism is essentially a biochemical machine. Man is no exception. This tardy discovery opened new avenues of thought and brought to light many new and hitherto unsuspected disorders. As a consequence, medicine is, at present, in a state of flux.

It has not been long since metabolic disorders went undiagnosed, even in *extremis*. At present, many are unrecognized beyond a chance of rehabilitation. In the main, this is due to improper evaluation of the chemico-regulating mechanism in the body economy. The nomenclature, as well, tends to defeat a more clear understanding. It is not unusual to hear physicians make a sharp distinction between metabolic and endocrine disorders when, as a matter of common knowledge, the endocrine system plays a significant rôle in body metabolism. Every endocrine disorder is, therefore, a metabolic disorder, although the reverse is not necessarily true. A classic endocrinopathy, upon which the popular conception of the

subject is erroneously based, is the end-result of a long-standing metabolic imbalance.

Metabolic disorder, as all chronic disorders, must have a beginning: like many another, the origin is frequently in childhood. Because of the fact that in many instances we are dealing with the mechanism essential to normal growth and development, one should, in disruption of this mechanism, expect to find some alteration of the soma. One does, but the discovery is often late. The reflection of a mild degree of metabolic imbalance on the soma is as insidious as development itself. To wait until all the classic features are reflected in the physical and mental make-up, before suspecting such a disorder, is to lose irreparably the most plastic period of the child's existence.

It is evident that, in order to preclude such an error, one should attempt to make a diagnosis as early as possible. Unfortunately, this is not easy. Laboratory methods, including the biochemical tests available, are unreliable, except in those conditions affecting carbohydrate metabolism. Basal metabolic rate determinations are discouraging in children below the age of eight. Anthropometric measurements, unless carefully interpreted, mean little. If we must, in final analysis, depend upon some alteration of the soma, the roentgenogram probably affords us the earliest and most conclusive evidence of the change. Roentgenologists may observe the bone changes in hyperpara-

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thyroidism long before the patient is incapacitated; and yet, through improper clinical correlation, the diagnosis is rarely made until the patient is badly demineralized. I believe that chronic hypervitaminosis may

resumption of growth, as the case may be. Putnam, Benedict, and Teel (6) have gone so far as to produce a condition simulating acromegaly. In their experimental animals osteophytic overgrowth is

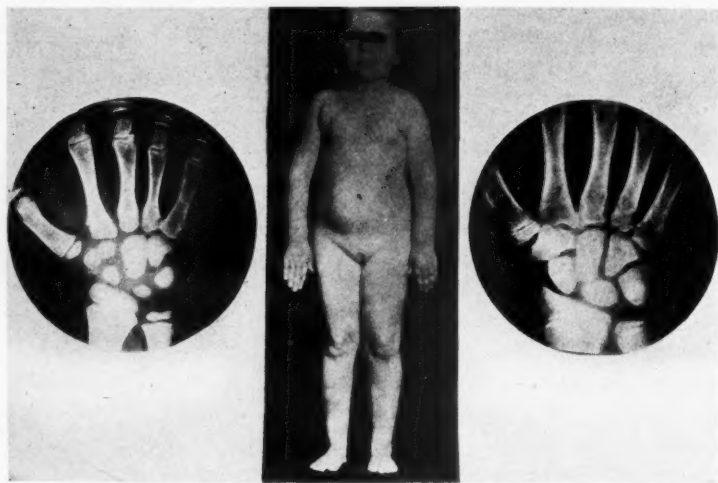


Fig. 1. A pituitary dwarf (age 9 years, 6 months), showing also the carpal development compared to normal. *Left*, patient's wrist; *right*, normal for age.

ultimately be found to be as evident. Rickets is better understood and rarely allowed to disfigure. There are other metabolic disorders of major importance which have been shown to affect the bony framework. Of these, two have recently been lifted somewhat from the realm of speculation.

From the time of Aschner (1) down to Reichert's (2) classic work, it has been demonstrated that the anterior lobe of the hypophysis is essential to normal growth and development. Ablation of the hypophysis results in dwarfism, a small bony framework, poor deposition of calcium salts, and late closure of the epiphyses. On the other hand, Evans (3, 4), Smith (5), Reichert (2), and others have produced the opposite effect. Artificial introduction of anterior lobe extracts into normal or even hypophysectomized animals results in overgrowth or

demonstrated, a density of framework with deposition of calcium salts throughout the body, and ultimate bridging and ankylosis of the spine. If these animals are injected before the epiphyses are closed, an early closure may be expected.

There is apparently some difference in the action of the thyroid hormone upon the bony framework from that of the hypophysis. B. M. Allen (7) has shown that the removal of the thyroid anlage in the tadpole interferes decidedly with its subsequent differentiation or transmutation, but until late in the condition not so much with its growth. Other observers point out that young thyroidectomized animals soon become cretinoid through improper tissue differentiation but do not immediately cease to grow. These same observers contend, however, that thyroidectomy ultimately results in atrophy of the hypophysis and that re-

removal of the hypophysis results in thyroid atrophy. If these things are true of the lower animals, they may equally be true of man. One unquestionably sees children suffering from mild degrees of congenital or

This is 92 per cent over the optimal increment for a normal at this age, and almost four times her previous rate of growth. You will notice by comparison with the normal that her carpal development at the be-

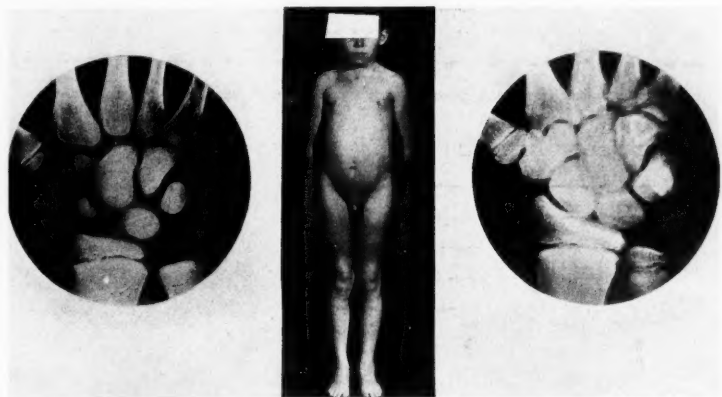


Fig. 2. A hypothyroid boy (age 10 years, 6 months), showing also the carpal development compared to normal. *Left*, patient's wrist; *right*, normal for age.

acquired hypothyroidism who are of average or nearly average height. In Switzerland, cretins are discovered of every size and description. On the other hand, one sees many pituitary dwarfs who present few hypothyroid stigmata. Granting that, in a terminal stage, all of these patients become bi-glandular because of this peculiar sympathy, how may one differentiate between the two early enough to insure a proper therapeutic régime? It is my belief that this may be accomplished in a fairly satisfactory manner through the roentgenogram.

I shall first present a child suffering from what we consider a deficiency of the anterior lobe of the hypophysis. She is at present 10 years and 6 months of age, and has been under observation for 9 months. The treatment has consisted solely of the introduction of a pituitary growth hormone perfected by Dr. Herbert Evans and his colleagues. During this period, we have been able to stimulate her growth 32 inches.

ginning of the observation, while small, was fairly complete (Fig. 1).

The next is a boy now 11 years 3 months of age. He is one of four children of a myxedematous mother, three of whom, I feel, are suffering from hypothyroidism. Compare his carpal development (Fig. 2) at the beginning of the observation with the normal and you will see that the carpal differentiation was five years retarded. Next, compare the stature of these children with their respective carpal development (Fig. 3). It is evident that the hypothyroid boy, while much larger in every respect, has not the carpal differentiation equal to the hypopituitary girl. Both are undoubtedly bi-glandular, but the paramount deficiency is brought out with considerable clearness in the roentgenogram. A comparison of the carpal development of the hypothyroid boy before and after 9 months' treatment with thyroid is next submitted (Fig. 4). The rapid unfolding is evident. It appears that

he has made a gain of several years in this short period. A comparison of the carpal development of the hypopituitary girl at the beginning of anterior pituitary substitution with that 9 months later shows only growth

I have not been able to secure a roentgenogram of the carpal development in one who has suffered from this condition any length of time. It is my belief, however, that such a roentgenogram would show a rapid un-

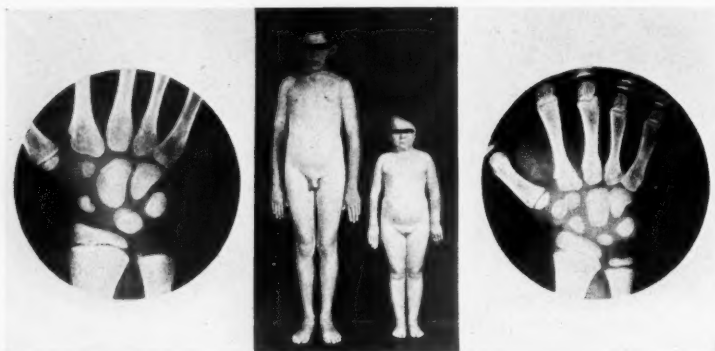


Fig. 3. Comparison of the stature and carpal development of a hypopituitary girl with a hypothyroid boy, both 10 years, 6 months old. *Left*, boy's wrist; *right*, girl's wrist. The osseous age of the boy is 5 years, 6 months; of the girl, approximately normal.

and better massing, since her differentiation was already nearly complete at the beginning of the experiment.

Macrogenitosomia has been attributed to dysfunction of almost every endocrine gland, and yet the one which could produce the entire symptomatology is rarely mentioned. A genital hormone, as well as a growth hormone, has been demonstrated in the anterior lobe of the hypophysis. In macrogenitosomia, or *pubertas præcox*, one sees a child who, at a certain stage of development, is not only very much larger than he should be, but has the genital development of an adult. The carpal development is also found to be advanced; indeed, so much so that the epiphyses close early and stop the growth in childhood. In comparing the wrist of a child of six, suffering from this condition, with the normal, and with that of a hypothyroid, one sees remarkable differences.

Hyperthyroidism is so rare in young children, and is usually discovered so early, that

folding of carpal development. It is quite possible that *pubertas præcox* cases have a high basal rate to account for a part of the rapid osseous unfolding. I can find no record of a case in which the laboratory procedure has been attempted in a closed chamber, although it probably has been done.

In carrying this study a step further, one comes to the period of adolescence and the epiphyseal closure time. It is well established that, after a certain age, the epiphyses start closing and a brake is put upon the long bone growth, an observation so thoroughly illuminated by Todd (9). Apparently no one understands this phenomenon, but it appears to be closely associated with gonad function. In cases of *pubertas præcox*, in which the gonads develop and function sometimes as early as the fourth year of life, the epiphyses immediately start closing. The earlier the onset of catamenia or the concomitant sexual ripening in the male, the earlier the epiphyseal closure. On

the other hand, if the gonad function is destroyed before or during adolescence, either through castration or through primary disease of the gonads, the epiphyses remain open until much later and the long bones

ysis. It would appear that in spite of a retarded differentiation of tissue in hypothyroidism, the epiphyses would close early. This is what I usually find, although I rarely consider a roentgenogram of diagnostic



Fig. 4. Roentgenograms of wrist of hypothyroid boy, before and after nine months of treatment. *Left*, before treatment; *middle*, after 6 months; *right*, after 9 months.

continue to grow. The result is eunuchism, or an individual of eunuchoid type. One should bear in mind, however, that the hypophysis is the activator of this entire process, even in the presence of apparently normal gonads. If the entire anterior lobe of the hypophysis is not functioning properly, the gonads will not function and the epiphyses may remain open for an indefinite period. There is a distinct difference between the two, however, both anthropometrically and roentgenologically. While the one is eunuchoid, with long slender bones and open epiphyses (castration—primary hypogonadism), the other remains small, with undeveloped bones and open epiphyses (underfunction of the anterior pituitary—dwarfism—secondary hypogonadism). There are many ramifications of this process which intrigue and baffle the investigator.

The thyroid hormone, on the other hand, appears to have an antagonistic effect upon the genital function, as evidenced by the early onset of catamenia in hypothyroidism—the excessive flooding of hypothyroid women, the cessation of menstruation and loss of libido in hyperthyroidism, etc. This is hard to explain in view of the supposed sympathy between the thyroid and hypoph-

ysis in any form of thyroidism after the age of twelve. By this time a basal metabolic rate is usually more informative.

In order to afford a better method of comparison between the normal and the abnormal in osseous development, I have recently devised a set of tables and charts of what I consider approximately the optimal. I have been criticized for allowing a liberal variation from these standards as being within the limits of normal, but I am still unconvinced that even a year is adequate in the younger ages. An unfinished study of 560 school children in whom we are attempting to correlate the bone age with the mental age and sex convinces us further that the subject is too new and entirely too complicated for dogma. The tables are subject to the same criticism as all other so-called normal standards and should be used with as much judgment and discretion.

It should be remembered that the cases featured in this discussion are more or less outstanding or classic. They have been selected in order to most clearly present my interpretation of the subject: there lies a wealth of material in between. Many metabolic disorders of importance have not even been mentioned, others only touched upon.

It is obvious that so large a subject could never be elucidated in a short paper.

In closing, I wish to say that while the effect of metabolic disorders upon osseous development is little understood, it is apparent. The subject is deserving of more serious thought and consideration. Only an open mind and a closer co-operation between the clinician, the biochemist, and the roentgenologist will ultimately decide the true value of osseous development as an index of metabolism.

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BIOLOGICAL EFFECTS OF VERY HIGH FREQUENCY ELECTRO-MAGNETIC RADIATION¹

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THE biologic effects of radiation in general are properly regarded as an investigative field of major importance. In the past, certain regions in the whole spectrum of radiation have been inaccessible to investigation because generators of frequencies corresponding to these regions have been lacking.

The advent of short wave radio-communication, brought about by the development, in the last decade, of the vacuum tube oscillator and the associated circuits, has permitted the generation of electro-magnetic radiation of frequencies which may be varied at will from less than 100 to about 400,000,000 cycles per second. Moreover, the radiations generated in this way consist

of continuous waves of relatively pure form, sharply emitted at the frequency to which the circuit is tuned.

In this respect the oscillations differ from those generated in the usual high frequency apparatus used for therapeutic purposes. Here the oscillations are produced by condenser discharge across a spark gap. Such oscillations have a large decrement; the wave form is impure, giving rise to many harmonics; the emitted wave is broad, and consistent operation at frequencies much above one or two million cycles per second is difficult to obtain. It is only natural that, with the development of means for the generation of very high frequency electro-magnetic radiation, the biologic effects of these oscillations should be investigated. Apparently the first paper on the biologic

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effects of such radiation was published in 1924 by Gosset, Gutmann, Lakhovsky, and Magrou (3), who reported the effects of very high frequency electro-magnetic radiation emitted by a vacuum tube oscillator upon plant tumors caused in the geranium by *Bacterium tumefaciens*. They reported that three geranium plants bearing tumors caused by inoculation with this organism were exposed to the radiations emitted by a vacuum tube oscillator at a frequency said to be about 150,000,000 cycles per second. One plant was given two exposures of three hours on consecutive days, one plant three, and one plant eleven such exposures. After 16 days from the first exposure the tumors, after growing in the interval, began suddenly to necrose. The necrotic process was said to be complete in about fifteen days so that the tumors could be detached by slight traction. In 16 control plants the tumors grew rapidly to great size and recurred after excision. The paper, however, contains no details as to the apparatus nor the method of exposure to the radiation.

In the Fall of 1924 the writer began his experiments on the action upon small laboratory animals of electro-static fields excited by very high frequency electro-magnetic radiation. As a preliminary to these studies, considerable work had to be done in testing the suitability of various types of oscillators for the work. Finally the type of oscillator described by Huxford (6) for frequencies higher than 60,000,000 cycles per second, and the well known Hartley circuit for frequencies lower than this were found to be satisfactory.

In these series of experiments, each mouse was placed in a box of insulating material of such size as to hold comfortably a 20-22 gram mouse, while permitting a minimum of twisting or turning. This box was inserted between the plates of a condenser which formed part of a circuit tuned to the frequency at which the oscillator was working.

When this circuit was inductively coupled to the oscillator, a current of the same frequency flowed in the circuit, the strength of which could be varied by increasing or diminishing the coupling. The strength of the current was measured by a calibrated platino-tellurium thermocouple, symmetrically inserted in the circuit.

It will be noted that when a mouse is enclosed in a box of non-conducting material exposed in this way to the action of the high frequency currents in the circuit, no free electrons from the external parts of the circuit can enter, nor can they flow out from the body of the experimental animal. The mice, however, were subjected to the action of a displacement current in which the electrons of the body cells, according to their state of freedom, would pass from molecule to molecule, or, if bound, be stressed in a direction the polarity of which alternates at the oscillator frequency. These conditions, therefore, differ considerably from those in the therapeutic applications of diathermy, for here the body part being treated is conductively connected in the high frequency circuit, so that the current flows through the intervening tissues.

When mice were exposed to high frequency currents in the manner just described, severe symptoms made their appearance, followed by death, if the exposure were prolonged more than a few minutes. Mice dying in this way felt warm to the touch, and rectal temperatures immediately after death ranged from 42.2° to 43.1° C. and occasionally to 44° C. The death of the mice, therefore, was due primarily to the heating effects of the high frequency electro-static field.

With sub-lethal exposures, in many instances, small hemorrhagic areas can be observed along the course of blood vessels of the ears which, in the course of 48 hours, become necrotic and drop off. The tail, too, frequently shows numerous ecchymotic

areas: it may subsequently become affected with dry gangrene and drop off. In other instances areas of alopecia develop, particularly in the supra-orbital region and at the tip of the snout.

In the course of preliminary observations, it soon became evident that the effects of exposure to different frequencies were not quite the same, a current of constant value proving more lethal at a given range of frequencies than at others. A series of experiments were, therefore, undertaken in which mice, under standard conditions of temperature and relative humidity, were exposed to the same current flowing in the auxiliary circuit (338 milliamperes), but in which the frequencies were varied in steps of about 10 per cent from a maximum of 135,000,000 to a minimum of 8,300,000 cycles per second.

As a result of these experiments, it was found that the lethal effect was most marked in a band of frequencies extending from about 66,000,000 to 18,000,000 cycles per second, the effect diminishing in one direction in the band extending from 18,000,000 to 9,000,000 cycles per second, and in the other from 66,000,000 to 135,000 cycles per second.

In view of the fact that, in the foregoing experiments, the lethal effect of some frequencies seemed more pronounced than that of others, the thought occurred that, under suitable conditions, oscillations at certain frequencies might prove more injurious to some tissue cells than to others; in other words, that there might be some differential action upon tissue with respect to frequency.

Evidently the tissue cells of transplantable tumors should form admirable experimental material for this purpose. Because of the high percentage of takes (averaging 95 per cent), the rapid rate of growth, and the relative rarity of recession (2 per cent), Mouse Sarcoma CR 180 was selected as the transplantable tumor for this purpose.

The preliminary experiments were carried out at practically uniform frequencies of from 66,000,000 to 68,000,000 cycles per second because the previous set of experiments showed that oscillations of this frequency were lethal to mice, and because of a highly speculative hypothesis (undoubtedly incorrect) that the mechanical rate of vibration of which a minute spheroid of the size of a tumor cell is capable might render it particularly sensitive to electrical vibrations of the same order of frequency.

The tumors were subjected to the action of high frequency currents in a tuned auxiliary circuit coupled to the oscillator, by means of copper electrodes (covered with an insulating varnish), which were applied, one on each side of the tumor and maintained in contact therewith. The currents registered by a thermo-milliammeter, placed symmetrically in the circuit, varied from 250 to 350 milliamperes and the duration of an exposure from 2 to 3 minutes.

A large number of mice (about 400) were treated in this way, with the result that about 100 mice, or 25 per cent, recovered from their tumors, and remained tumor-free. When properly carried out, the treatment seemed to cause the mice no pain, and, while immediately after the treatment the tumor felt softer and smaller to the touch, at least the rise in the local temperature was trifling. In some instances a single treatment caused shrivelling and drying up of the tumor; in others, several treatments were required.

In collaboration with Dr. H. B. Ander-vont (20), of the Department of Preventive Medicine and Hygiene of the Harvard Medical School, the effects of the same method of treatment upon the Rous fowl sarcoma planted in the skin, comb, and wattles of chickens were studied. In seven chickens which were inoculated a total of 15 times, it was possible to bring about by the treatment just described a complete re-

cession of the tumor, while in an equal number of chickens, one inoculated in the comb, one in the wattle, and five in the skin of the breast, only retardation of the tumor growth was produced, the fowls ultimately dying from extensive tumor growth.

Later on it was found in the case of mice inoculated with Mouse Sarcoma 180, rats inoculated with Rat Sarcoma No. 10, and also chickens inoculated with the Rous fowl sarcoma, that frequencies between 90,000,000 and 100,000,000 cycles per second were considerably more effective in treating these tumors than the range of frequencies 66,000,000 to 68,000,000 cycles at which the preliminary experiments were carried out. With the higher frequencies, from 60 to 75 per cent of recoveries were obtained in tumors ranging from 15 to 20 millimeters in length for mice and from 30 to 50 millimeters in length in rats.

Mention has already been made of the fact that, after treatment, the temperature of the tumors did not appear sensibly raised to the touch. However, tactile impressions are often notoriously false, so observations were made as to the temperature rise taking place in the interior of the tumor during treatment. This was carried out by inserting a thermocouple made of an insulated constantan wire in the interior of a 22-gauge hypodermic needle into the interior of the tumor along its long axis. By this means it was found that although the skin was but little heated by the high frequency field, the temperature in the interior of the tumor rapidly rose, reaching from 48° to 49.6° C. in from one and a half to two minutes, according to the size of the tumor. Other experiments made by immersing tumor fragments in Locke's solution heated to various temperatures for various times showed that heating fragments of mouse sarcoma to temperatures between 48° and 49° C. for 3 minutes prevented their growth when transplanted into mice.

It is evident, therefore, that the curative effects noted were due to the heating of the tumor cells in the high frequency field. Incidentally it may be remarked that it was also found possible to bring about the recession of tumors by placing on each side a hollow copper applicator through which hot water was circulated until the temperature of the interior of the tumors, as shown by an inserted thermocouple, had reached from 48° to 49° C. However, it took a considerably longer time to raise the internal temperature of the tumor the required amount by this method than by the action of the high frequency currents.

In 1929, Christie and Loomis (2) repeated the writer's experiments on the heating effects of a high frequency field on mice, investigating in similar fashion the effect of frequencies varying from 150,000,000 to 7,000,000 cycles per second. Their results were definitely at variance with those obtained by the writer in that, with fields up to a frequency of 50,000,000 cycles, they found the lethality of the field to be proportionate to its intensity, one frequency being just as lethal as another; above 50,000,000 cycles, however, the lethality of the radiation appeared to diminish. They believed that one source of error in the writer's experiments was the carrying out of the observations at constant current, determined by a thermocouple symmetrically located in the circuit. Instead, they adjusted the circuit in which the mice were exposed at different frequencies, so that a M/20 salt solution thermometer held in the condenser field showed a temperature rise in degrees centigrade per minute of the same order at each frequency investigated.

However, as pointed out by McLennan and Burton (13), this, too, leads to erroneous conclusions, since, as will be more fully discussed, the rate of heating of a solution of electrolyte of a given concentration changes with the frequency.

In 1928, Dr. W. R. Whitney, Director of the General Electric Company's Research Laboratory, observed in connection with test runs of a 20-kilowatt short wave oscillator that the mouth temperature of one bystander rose 2.2° F. in 15 minutes, while several other individuals exhibited a somewhat smaller rise in temperature. It was also noted that solutions of electrolytes of different concentrations, when placed in the electro-static field of the oscillator, did not heat alike, one concentration heating faster than another at one frequency, while this relation might be reversed if the frequency were sufficiently changed.

These observations have led to two lines of investigation: (1) the study of the heating of electrolytes in high frequency fields, and (2) investigation of the use of the high frequency electro-static field as a means of producing artificial fevers for therapeutic purposes in human beings.

The heating of electrolytes in high frequency electro-static fields was first investigated by Hosmer (5) and then, among others, by Richards and Loomis (17), McLennan and Burton (13), and more recently by Pätzold (16).

Without taking the time to describe the methods employed, nor to discuss the mathematical analysis of the results, the main facts shown by these inquiries are, according to McLennan and Burton (13), as follows: The heating of a solution of electrolyte in a high frequency electro-static field depends, not upon the composition, but on the specific conductivity of the liquid, and rises to a maximum for a certain conductivity whatever the size and shape of the specimen heated. The conductivity at which the maximum effect occurs is proportional to the frequency, *i.e.*, at lower frequencies the maximum heating is observed in solutions of lower concentration than at higher frequencies. For example, at 1,560,000 cycles per second the concentration of potassium chlorid showing a maximum heating effect

is 0.00038 gram-molecules per liter; at 5,560,000 cycles it is 0.002, or five times greater; at 22,000,000 cycles, the concentration is about 0.005, and at 26,100,000 cycles it is about 0.01. In the neighborhood of 300,000,000 cycles, according to personal observations, this concentration is about 0.1.

For the low conductivities involved, the so-called "skin effect" is shown both by experiment and theory to be negligible and the heating effects are produced throughout the depth of the specimen to be heated. Inasmuch as the intensity of the field within the specimen is influenced by its orientation with respect to the external field, this too is important, the heating effect observed depending both upon the di-electric constant and the shape and orientation of the external field. In a heterogeneous body, such as that of a laboratory animal, the distribution of the field in the interior of the body will be determined largely by the respective di-electric constants of its component tissues; the degree of heating at that particular frequency by their respective conductivities.

McLennan and Burton (13) point out that if we knew the electric properties of the component parts of the body, we would, by the proper choice of frequency, be able to favor the heating of one portion over the other, although the effect of such selective heating would tend to be minimized by heat exchange between neighboring parts. Nevertheless we have here a therapeutic possibility which, if susceptible of development, would have a wide application.

Artificial Fevers.—The rapid heating of the animal body in the high frequency electro-static field has been utilized by Carpenter and Page (1) in the production, for therapeutic purposes, of artificial fever in man. Basing their work on Whitney's observations of the elevation of body temperature of persons working in the field of a powerful short wave transmitter and using apparatus designed by the Research Laboratories of the General Electric Company, they have

been able, by proceeding cautiously, to produce and maintain for several hours artificial fevers of from 104° to 105° F. In their experiments they found a frequency of about 10,000,000 cycles the best adapted to their purpose, the subject being placed between condenser plates 28 × 18 inches covered with hard rubber to prevent contact burns, the subject, with the exception of the head, inclosed in a box of non-heat-conducting material. Carpenter feels that this method for the production of artificial fevers may in the future be susceptible of wide therapeutic application.

At the present time clinical applications of this method of producing artificial fevers are being investigated at several medical centers, notably at the University of Rochester, where, under the direction of Carpenter, Murlin, and Warren, both laboratory and clinical studies of the therapeutic possibilities of the method are under way. At a symposium held at the University of Rochester in May, 1931, clinical demonstrations were made of the favorable effects of such fevers upon paresis, gonorrheal arthritis, syphilis, and rheumatic arthritis. The results were such as distinctly to encourage the investigators to continue their inquiry.

With respect to the possible therapeutic applications of the high frequency electrostatic field, we should keep the following in mind: In the first place, the heating is produced in a somewhat different manner than in ordinary diathermy. In conventional diathermy there is a current flow between the electrodes and, though it cannot be denied that the capacity of the tissues and their dielectric constants play some part in the heating process, still, at the relatively low frequencies employed, and at the concentrations of electrolytes prevailing in the tissues and body fluids, these effects are small, compared to the heat generated by the resistance of the tissues to the current flow.

Schliephake (21-23), in 1928 and 1929, has compared the relative heating of vari-

ous kinds of tissue both in the condenser field and with conventional diathermy. He finds that, in the condenser field, the heating is more nearly uniform than in diathermy, in which there is excessive heating of the subcutaneous tissues, as compared to the heating in the intervening portions of the body. For this reason it would seem practicable, from the action of the high frequency condenser field, to raise the temperature of deep-seated organs to a considerable degree without, at the same time, overheating the subcutaneous tissues.

So far we have concerned ourselves only with the heating effects of the high frequency condenser field. Christie and Loomis (2) and Kahler, Chalkley, and Voegtlin (7), who, in 1929, studied the effects of the high frequency condenser field upon the unicellular organism *Paramecium*, came to the conclusion that no other than a heating effect was demonstrable.

However, in 1930, Mellon, Szymanowski, and Hicks (14), following up the work of D'Arsonval, who found, about thirty-five years ago, that high frequency currents of about 200,000 cycles per second diminished the strength of diphtheria toxin, carried out a series of experiments, using a frequency of 158,000,000 cycles per second, in which diphtheria toxin was exposed in a film about 0.5 mm. in thickness between the walls of concentric tubes, while a chilled fluid was circulated in the inner tube. The type of fluid chosen for cooling was important because absorption of the electro-magnetic waves by the central core of cooling fluid might condition a loss of energy available to affect the toxin. Benzol was chosen because its balanced molecular structure gives rise to no resultant dipole, and since its dielectric constant is the same at all frequencies, no absorption bands were to be anticipated. It was found that the radiation was effective in reducing the activity of the toxin even at temperatures as low as 15° C.

McKinley (12), in 1930, also reported

certain results as indicating a possible specific action. Exposure of the whole of the vertebral column of the frog at 90,000,000 cycles per second resulted in all cases in an immediate response, the effect being a violent muscular contraction of the hind legs. The experiments were repeated with external heat as the agent, and the characteristic reaction of the leg muscles, as observed in the high frequency condenser field, failed to take place.

The writer has found that, when a Straub preparation of a frog's heart is placed in a high frequency condenser field at 90,000,000 cycles per second, the heart, after undergoing a period of acceleration in its beat, stops in diastole, frequently showing a 2:1 heart block before the arrest. Upon cutting off the current the beat is resumed, returning to normal after a brief preliminary irregularity. It is possible to obtain this effect on the heart if the Ringer's solution used to perfuse the heart and to drip on its exterior (to avoid drying) is chilled to 4° C. Control hearts were either perfused with gradually heated Ringer's solution or suspended in a gradually heated air chamber. In the first instance, after preliminary acceleration, irregularities in the beat began to be manifest at a temperature of 41° C., but arrest of the heart's action took place only when the Ringer's solution was preheated to 47° C. In the hot air chamber it required an external temperature of approximately 50° C. to arrest the heart.

These experiments, however, are put forward with reserve, as it required considerably more current in the coupled circuit to stop the heart when the Ringer's solution was chilled than when it entered the heart at laboratory temperature (about 20° C.), so it is possible that the observed effects may have been due to heating of the conducting bundles.

At this point the observation may be mentioned that the heating effects of the high frequency condenser field upon nervous

tissue are pronounced. Schliephake (21-23) in his studies found that the heating rate for brain tissue is high. Headlee and Burdette (quoted by McKinley) found, in 1929, that of many organic chemical compounds which they measured, cholesterol, which is characteristic of nervous tissue, has the highest heating rate.

McKinley (9-11) found, in exposing insects to the action of the high frequency condenser field, that in holometabolous insects, in which the nervous system is more highly organized in the adult than in larval forms, the time of lethal exposure was about six times longer in the larva than in the adult. In hemimetabolous forms, in which but little difference exists in the nervous organization of the adult and the nymph, the lethal time was about the same.

Such, then, is the status of our present knowledge in regard to the biologic action of ultra-high frequency electro-magnetic waves. It appears to be a field which is worthy of investigation, and one which, in the future, may well provide valuable therapeutic aids.

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HERNIA OF THE LUNG

ROENTGEN OBSERVATIONS, WITH REPORT OF A TRAUMATIC CASE

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ANY part of the pleura-covered lung which protrudes beyond the normal boundaries of the thoracic cage and invades the subcutaneous tissues can rightfully be designated as a true hernia. True lung hernia should not be confused with evisceration or prolapse, an error not infrequently made by early writers. Lung hernia is a very rare condition; up to the present time, less than 200 cases have been reported in the literature. Because of its rarity, clinicians of wide experience have had little opportunity to observe it. Much information in the literature is inaccurate and confusing and, therefore, some early reports are not dependable. Several names have been applied to lung hernia, as pneumocele, pneumocele, and pulmonary hernia.

Considering the great number of stab and bullet wounds in warfare and civilian life, and crushing injuries of the chest, it is surprising that lung hernia is not more frequent. In an extensive war experience with chest wounds, Makins observed one case, while Adams reported five out of 20,000 chest wounds in the Russian-Japanese War (1). It is also noteworthy that, with frequent fractures of the ribs, pneumothorax rarely occurs. In a study of 89 cases of fractured ribs requiring hospitalization, 16 were treated for other complications but only one instance occurred in which pneumothorax resulted (2).

HISTORY

As early as 1891, Rolandus published a report of the first case operated upon for

lung hernia (3). Chassier mentions herniated lung and was one of the first to accord it special consideration (4). Cloquet, in 1819, reported a case of a young man, age 32 years, crushed under a gun carriage, who made a good recovery (5). Morel-Lavallée, who collected 32 cases, gave us a very comprehensive classification (6). Lake mentions a case of lung hernia caused by the handle of a wheelbarrow penetrating the side of the chest (7). Dufour reports a case of traumatic hernia cured without operation, after much loss of blood (8). In 20,000 wounds in the War of the Rebellion, only seven lung hernias were reported. Cockle published a case of double pulmonary hernia (9). Lewtas (10) and Hirschsprung (11) each reported a case of congenital hernia. Spontaneous pneumocele from violent exertion in weight lifting was reported by Masoti (12). Hagentorn (13) mentions pneumotomy in pneumocele. In 1893, Pitt (14) affirmed that the protrusion of hernia may occur at the time of trauma or any time later. Lopez (15) reported resection of the lung for hernia, with recovery. Tuffier (16) mentions resection of the lung and Knox (17) reported two cases of hernia of the lung into the neck. From 1895 to 1904 several cases of hernia of the lung and its treatment were reported (18, 19, 20, 21, 22). Vulpus (23) reported a case of traumatic hernia of the lung which, five weeks after plastic operation, was discharged, cured. Koennecke (24) reports a case of strangulated, pulmonary hernia occurring in a male of 39 years, of sedentary occupation, in whom the protrusion appeared suddenly from over-exertion. The lungs and thoracic wall were otherwise unaffected. The swelling, which was of six months' duration, was observed to become irreducible on the morning before the patient's admission to the hospital. The man suffered shooting pains in respiration, cough sensation, and pains which radiated into the

arm, becoming most violent in the prone position. A painful, egg-shaped protrusion of pillow-like consistency above the left clavicle was removed and the slit of 2 cm. in the pleural cavity was sutured and covered with a flap of muscle from the sternocleidomastoid. The patient made an uneventful recovery. The author considers this a congenital or a spontaneous lung hernia since he was undetermined whether the pleural gap, the place of predilection for hernia, had been congenital or had originated from previous trauma from over-exertion. In the opinion of the writer, this can be considered a spontaneous hernia, since the weak spot of *locus minoris resistentie* existed as shown by the congenital defect where anatomically a weakened area occurs.

Morel-Lavallée made the following classification:

I.—According to Location

- (A) Diaphragmatic
- (B) Thoracic
- (C) Cervical

II.—According to Etiology

- (A) Congenital
- (B) Acquired
 - 1. Traumatic
 - 2. Consecutive
 - 3. Spontaneous
 - 4. Pathologic.

Most authors abide by this grouping, although some object to the *consecutive type* since it invariably follows cases of traumatism (6).

CONGENITAL LUNG HERNIA

Hochsinger (25) regarded all lung hernias as congenital during the first weeks of life. Congenital pneumocele is due to defective development in any portion of the thoracic wall. These defects, which are covered by fibrous tissue, arise from intra-uterine abnormalities such as amniotic

bands, pressure of fetal limbs against the chest wall, pressure from uterine masses or fibroids, and a lack of amniotic fluid. *In utero*, with the lungs solid and in a state of collapse, no evidence of hernia is noted. The individual may grow to adult life before signs of hernia first appear and, because of this, confusion may arise as to its congenital origin.

The hernia may be cervical, thoracic, or diaphragmatic in location. Beale (26) reports the only recorded case of diaphragmatic hernia, following an injury to the diaphragm through which lung protruded, with intestinal perforation and a subphrenic abscess. The patient succumbed to general peritonitis. Postmortem revealed the lung tissue in the subphrenic abscess but no opening in the diaphragm was found. The cervical group is relatively rare; the thoracic is most common. Montgomery and Lutz (27), in an extensive review of the literature, made a statistical study and reported 165 cases, citing one in detail.

165 Cases Reported

Congenital	18 per cent
Traumatic	50 per cent
Spontaneous	32 per cent
Cervical	16 { Left..... 6 Right.....10
Anterior chest wall	57 { Left.....23 Right.....34
Posterior chest wall	5 { Left..... 2 Right..... 3

ANATOMIC CONSIDERATIONS

In the congenital group, the extension of the pleural sac into the neck favors this site as the most common location. The dome of the pleura limits the excursion of the apex of the lung, strengthened by the deep cervical fascia and the adjacent neck muscles. The weakest region is the area between the scalenus anticus and the sternomastoid muscles; therefore, hernia usually

occurs at this site. Near the sternum and the vertebræ anteriorly and posteriorly are two other weak sites. Anteriorly the costal cartilages lack the group of external intercostal muscles; posteriorly the internal groups extend only to the angle of the ribs. Herniation occurs more commonly anteriorly, since the pectoral group of muscles does not afford the wall of resistance offered by the strong back muscles, namely, the latissimus dorsi, the trapezius, and the rhomboideus.

Most writers are agreed that a hernia of the lung is dependent upon a *locus minoris resistentiæ*, such as occurs in the wall of the thoracic cage, associated with an increased pressure within the lungs themselves. Pressure changes are due to either voluntary or involuntary contractures of the muscles of the chest wall, combined with varying degrees of closure of the glottis. Long continued strain, especially that applied day by day, is responsible for the production of all hernias and this is applicable, in a great measure, to pneumocele (28).

SPONTANEOUS PNEUMOCELE

When any weakened portion of the chest wall gives way under the strain of increased intrathoracic pressure, a spontaneous hernia occurs. The *locus minoris resistentiæ* pre-exists, to which is added an abnormal increase in the intrapulmonary pressure—two factors which must be present to cause a spontaneous hernia. Anatomically, diastasis of muscles, absence of ribs, or any defect in the structure of the thoracic wall have been reported as etiologic factors. Persistent paroxysmal cough—as in bronchitis, bronchial asthma, whooping cough—lung suppuration, or tuberculosis, etc., may be the exciting cause. Common causes, such as blowing of glass and musical instruments, heavy lifting, muscular strain at labor, have all been mentioned. Wightman (20) records the case of a flute player who developed a

spontaneous pneumocele. Again it is recorded in a case of tuberculosis, developing secondarily to the chronic cough (29).

PATHOLOGIC PNEUMOCELE

Some authors are of the opinion that lung hernia may be caused by the following pathologic conditions: rupture of a lung abscess through the pleura and chest wall, abscess of the chest wall and breast, suppuration of lung breaking through the chest wall, the latter sometimes associated with degenerative malignancy, and empyema, with complications invading the chest wall and lung.

TRAUMATIC PNEUMOCELE

Lung hernia following injury presents by far the greatest number of acquired cases; stab wounds and crushing injuries of the chest, with gunshot and shrapnel wounds, form the most common etiologic factors. Lung hernia in scars and following operations on the chest, as the Estlander operation, have been reported. Severe contusions of the chest arising from injuries such as squeezing forces, the being hurled against seats, other persons, or a car may result, not only in fractured ribs, but in serious damage to the viscera. A wound of the pleura is usually associated with a wound of the lung. Rupture of the lung or diaphragm may occur with little evidence of external injury (30). Hernia of the lung may develop quickly, or after a considerable interval.

SYMPTOMS

Generally speaking, there may be no symptoms. Pain, aggravated by deep breathing or cough, may occur over the site of the impending hernia during its development. In the author's case, no pain was experienced by the patient when the hernia became fully developed, but during the first week great pain was experienced,

first, from recovery from shock, secondly, pleural involvement, and, lastly, paroxysmal cough which was troublesome and increased the pain. Due to the bronchial fistula communicating with the pleural cavity, there was abundant expectoration. As a rule, however, with no pleural involvement, especially in the spontaneous pneumocele, the cough is hard, spasmodic, and unproductive. Early traumatic hernias are not detected, as a rule, since the signs and symptoms are masked by those of injury. Localized pain may be the first sign of hernia, verified later by a bulging mass the size and shape of which alter with respiration.

Distress caused by pulmonary hernia may consist of local pains during forced breathing and coughing spells. Pain may be pronounced at first, when the hernia suddenly develops, and later may disappear altogether. In cases of concurrent bronchitis, repeated hemoptyses have been observed. Several cases of this type, in which the symptoms have disappeared following treatment or operation, have been reported.

PHYSICAL SIGNS

The soft, crepitant, bulging mass in the chest wall, increasing in size during expiration, exertion, and cough and diminishing during inspiration, is pathognomonic of lung hernia. Montgomery and Lutz (27), Garré and Quincke (31), Lilienthal (32), Morriston Davies (33), Smith and Johnstone (29), and others describe these phenomena. These same respiratory signs were likewise observed in the author's case. The size of the tumor varies from that of a small egg to that of an orange, or baseball, and even larger; the pneumocele may be single or multiple, unilateral or bilateral, and may, or may not, be enclosed in a sac (29).

The orifice of the pulsating mass of lung is usually palpable and the bony or fibromuscular margins can be readily made out; its size, of course, varies with the size of

the protruding lung tumor. Due to a weakening of the chest wall, either a defect due to injury or of a congenital nature, sometimes a depression is seen during forced inspiration, wherein the tumor may actually retract and may be covered only by skin and a few strands of "thinned out" superficial fascia. It is readily reducible and recurs easily. When the hernia follows a wound caused by some penetrating instrument the lung is not covered by parietal pleura and consequently becomes adherent to the wound (31). If the wall of the tumor orifice becomes inflamed, adhesions may follow and the pneumocele may become incarcerated and irreducible. Although strangulation has been reported, Lilienthal considers this a very rare incident since the lung retracts readily because of its elasticity.

The pneumocele is usually covered by unbroken skin beneath which may be a few thin strands of fibromuscular bands; to the touch it feels soft, spongy, and smooth. Deese reports a lung tumor pedunculated and herniated and dark violet in color (34). In the writer's case the cavity of the pneumocele contained fluid and air, probably the first recorded instance, as no mention in the literature or text-books is made of this complication; two other fluid level pockets were also present. Reducing the mass by manipulation, one was able to penetrate the orifice of the cavity to a depth of about 3.5 centimeters. Most writers claim that the protruding, herniated lung can be grasped and readily recognized as lung tissue by its crepitant character. The lung tumor, as a rule, is tympanitic in note, and whistling; crackling râles may be heard while it is being held. Percussion elicits a peculiar tympanitic note and fremitus is usually increased. Pockets of emphysematous air in the subcutaneous tissues, when palpated, reveal the distinctive crepitation and crackling sounds with respiratory changes absent (34).

ROENTGEN SIGNS

Fluoroscopic observation reveals interesting phenomena during respiration. At the site of the hernial bulge only normal or increased radiance is visible in the anteroposterior position. In the lateral or oblique positions, on the tumor side, a bulging pocket of air can be noticed readily in the thoracic wall—the mass increasing in size, especially during forced expiration, muscular exertion, and cough. If it is not bound down by adhesions, the tumor mass can be reduced and held in place by several fingers over the palpable orifice, usually located between the ribs. A bony irregularity may sometimes be felt. If the bulging air pocket contains fluid, a fluid level can be observed which changes with position. In the oblique and lateral positions on the affected side an air pocket is seen in the thoracic wall with the *bulge greatest in forced expiration and smaller, flat, or retracted forced inspiration*. In the anteroposterior plane, at the site of the hernia, an area of increased radiance may be observed, the pleural cavity on the affected side containing fluid and air (author's case). A fluid level is present, the chest showing the usual homogeneous density. In the author's case, another fluid level pocket was recognized, probably behind the sternum, adjacent to the hernial bulge.

CONDITIONS CONFUSED WITH HERNIA

Among these conditions may be mentioned subcutaneous emphysema, empyema necessitatis, lung abscess, or pulmonary supuration perforating into the chest wall, tumors of the thoracic wall, pulmonary tuberculosis, caries of the rib, and gas bacillus infection. Bulgings observed about the clavicle in tuberculosis, with prolonged cough and emphysema, are not true herniae, although occasionally hernia may develop in this region.

Subcutaneous emphysema may cause a



Fig. 1 (*top*). Film made three days after the accident. There were noted: fracture of the ribs, ruptured pleura and lungs, right-sided pyopneumothorax, and extensive interstitial emphysema.

Fig. 2 (*bottom*). Three days after the accident. Note the extensive interstitial emphysema.

bulging in the chest wall. In crushing injuries of the thoracic wall in which the soft tissues are involved, small affected areas may coalesce. These are crepitant on palpation, tympanitic in note, with audible and readily displaced bubbles of air. Gas bacillus infection may simulate this condition and sometimes masks the picture, but no phenomena occur with respiration (35, 36).

A puncture wound, traumatic or operative, may sometimes give rise to this condition. Subcutaneous emphysema commonly follows paracentesis of the chest; it also sometimes follows trauma or a violent

coughing paroxysm and is often seen over the lower part of the neck and manubrium. It may occur in influenzal pneumonia, often spreading over the chest and abdomen. In empyema necessitatis, a bulging external tumor may simulate hernia; the tumor may increase or diminish in size during coughing or forced breathing. To differentiate tumors of the chest wall from hernia, dependence must be placed on the presence or absence of crepitation and the other signs commonly found in hernia. One case of tuberculosis is cited in which ulceration had destroyed a portion of the intercostal muscles, leaving only the skin and subcutaneous tissues covering the lung; during inspiration and cough there was a distinct bulging but the tumor mass lacked the characteristic crepitation of hernia (1).

My thanks are due Dr. Andrew J. Brislen for his many valuable suggestions and for the privilege of reporting the following case. I wish also to convey my thanks to Dr. Carl Hedblom, to whom I cited the history of the reported case and who viewed the roentgenograms. To Dr. James G. Montgomery, of Kansas City, Missouri, I am equally grateful for his expression of opinion by correspondence.

SUMMARY

A brief history of lung hernia is cited and Morel-Lavallée's classification is recorded. The anatomic considerations, the symptoms and the physical signs are enumerated. The respiratory phenomena as observed in the protruding lung hernia may be considered pathognomonic. Finally the roentgen signs are described and evaluated. The author's personal case is appended.

CASE REPORT

W. N., a mechanic, was admitted to Woodlawn Hospital on Sept. 30, 1931, with a clinical diagnosis of crushing injury to the right chest. Three days previously his car

had turned completely over. The man was picked out of the wreckage, severely injured, and taken to a neighboring hospital where he remained several days. Becoming dissatisfied, he boarded a train for a 14-hour journey to Chicago. He was admitted to Woodlawn Hospital on the afternoon of his arrival in the city.

Physical Examination.—The patient, a male, age 42 years, weight about 140 pounds, was in extreme pain and grunted with each respiration. He assumed a crouching position; his face was a dusky hue. Labored respirations, 32; temperature, 101.4; pulse, 108. Subcutaneous emphysema existed in a marked degree from the lower jaws to the iliac crests. In the proximity of the third rib, on the anterior chest wall, a small, superficial wound, 2.5 cm. in length, and a contused area, 5 cm. in diameter, were seen. The right second intercostal space anteriorly was depressed, but bulged somewhat on expiration. The heart was dextro-displaced 2.5 centimeters. Subsequently this was ascertained to be due to a moderate degree of scoliosis. Respirations were somewhat superficial and labored; when deeper, dyspnea and excruciating pain were present. Cough with expectoration of a bloody type was present. No cyanosis existed but the patient did not seem any too well aerated.

Chest.—The right thorax was tender to palpation and percussion, particularly anteriorly. Dullness on percussion was present over the lower half of the chest, both anteriorly and posteriorly, with absence of fremitus. A distinctly tympanitic area, most marked between the anterior and posterior axillary lines, superimposed on the dull area, was noted. On auscultation, breathing sounds were bronchial in character and intensified, these conditions being most marked over the right upper thorax; here numerous moist râles were heard. Breath sounds

were absent over the lower half of the right chest.

X-ray Examination.—Sept. 30, 1931. Upper thorax: there was definite pathology involving the entire right chest with the exception of the extreme apex, which showed marked infiltration of the soft tissues with air. The soft tissues of the anterior chest wall and in the region of the axilla as far down as the tenth rib showed cutaneous emphysema. Owing to the scoliosis in the lower left dorsal vertebrae, much of the shadow of the right heart was seen; the heart was, however, in its normal position. There appeared to be angulation of the ribs from the second to the fifth, inclusive, in about the anterior axillary line in comparison with the corresponding areas of the left side. This was indicative of fracture. The lower three-fourths of the right chest was occupied by a dense, homogeneous shadow through which were seen irregular areas of air mingled with areas of emphysema in the soft tissues of the chest wall. This shadow obliterated the diaphragm and the costophrenic angle. Lower thorax: The emphysema had invaded the soft tissues of the left lumbar region. There was marked scoliosis in this region which caused a deformity of the lower ribs, but there was no evidence of any fracture.

Summary.—Upper thorax: multiple fractures to the right anterior ribs; fluid in the right pleural cavity; injury to the right lung; cutaneous emphysema in the right chest wall; traumatic pneumocele of the right lung; old scoliosis. Lower thorax: cutaneous emphysema (Figs. 1 and 2).

From these findings the following diagnosis was made:

1. Contusion and small lacerated wound of the right anterior chest wall with destruction of some of the intercostal tissues at the second and third ribs.
2. Multiple fractures of the right anterior ribs.

3. Injury to the right lung, inducing bronchial fistula, open pneumothorax, and hemothorax.

The cough persisted, though it was better controlled after the first few days. The hemoptysis gradually subsided until approx-

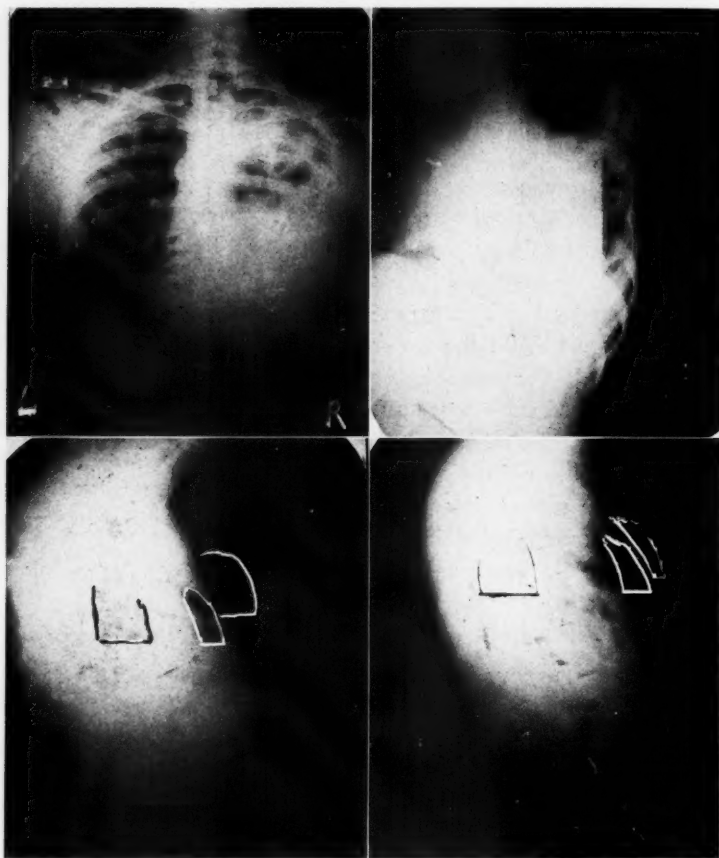


Fig. 3 (*upper left*). Erect position. Note the large, right pyopneumothorax and the two fluid levels.

Fig. 4 (*upper right*). Right lateral recumbent position. Note the two fluid levels in the upper lobes and the third in the pleural cavity. The largest cavity in the upper lobe corresponds to the bulging on the right anterior chest wall at the second interspace.

Fig. 5 (*lower left*). Forced expiration, lateral, right. Note the large pocket in the anterior chest wall and behind the sternum; also the third pocket and fluid level in the pleural cavity.

Fig. 6 (*lower right*). Forced inspiration, lateral, right. Note the collapsed pocket on the anterior chest wall.

4. Subcutaneous emphysema extending from the lower jaws to the iliac crests.

5. A pulmonary hernia.

Course and Progress.—The dyspnea and the chest pain improved after a few days.

imately the fifteenth day, when it ceased to be a factor. The expectoration varied from purulent, blood-tinged to clear mucus through the subsequent course. During the first week the bulging in the region of the

second and third ribs increased, attaining approximately the size of a baseball, growing smaller with inspiration, but exceedingly

It may be well to note the fact that aspiration of 915 c.c. of pus with the replacement of an equal amount of air was done on

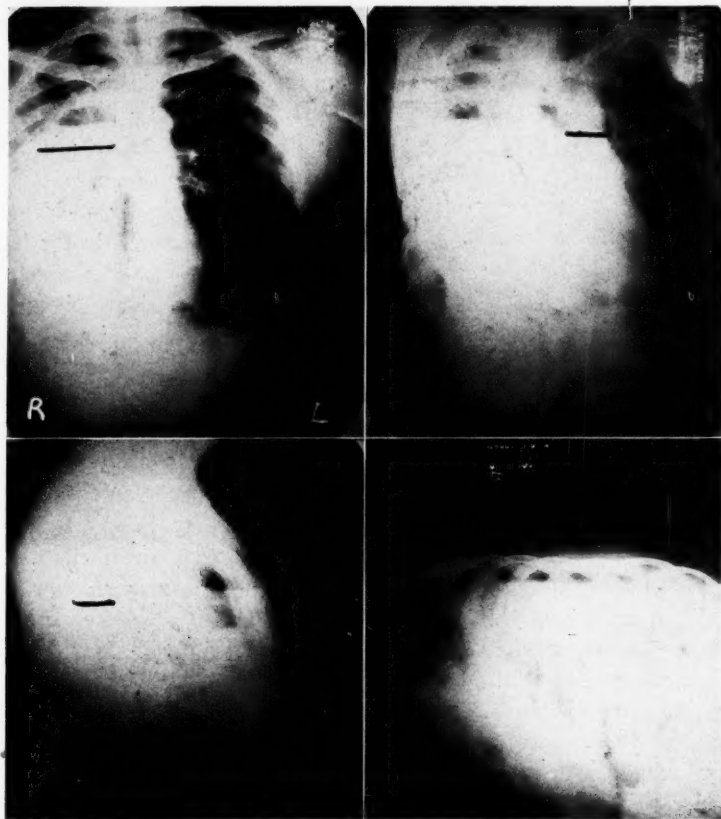


Fig. 7 (*upper left*). Erect position. Large right pyopneumothorax. Note the pocket of second fluid level at the second anterior rib.

Fig. 8 (*upper right*). Right anterior oblique (erect). Note the two fluid levels.

Fig. 9 (*lower left*). Forced inspiration, lateral. Right lateral erect position. Note the three fluid levels.

Fig. 10 (*lower right*). Right lateral recumbent position. Note the fluid level of the pyopneumothorax.

tense and larger with expiration and cough. A pad of the hernial type was strapped over the lesion, compressing the hiatus between the second and third ribs, with a visible improvement in comfort to the patient. Irregular temperature of a septic type persisted through the six weeks of hospitalization, declining during the last 10 days to a practically normal temperature.

October 22, at the time of the lowest white count. A direct smear showed numerous pus cells, but no organisms. Incubation of 76 hours showed no growth.

X-ray Examination.—Oct 12, 1932. The lower one-half of the right chest was occupied by a dense, homogeneous shadow obliterating the ribs, diaphragm, and costophrenic angle, and showing a definite hori-

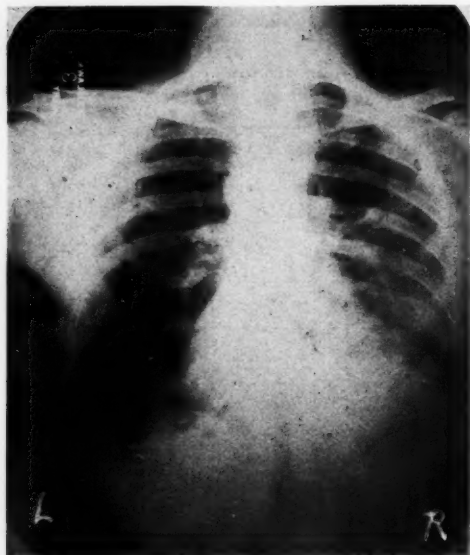


Fig. 11. Erect position. There is absence of fluid in all pockets. The entire right chest is re-expanded except for residual, thickened pleura and high diaphragm at the right base.

zontal level. With agitation, definite fluid waves were seen. An oval shadow of rarefaction, which corresponded to the bulging air pocket in the anterior chest wall, was seen above this level. With the patient in the right lateral recumbent position, examination revealed considerable pneumothorax with three definite fluid levels, the one of the pneumothorax; the second, the pocket of air and fluid on the anterior chest wall, and the third, a pocket of air and fluid beneath the second portion of the sternum. Lateral views showed that forced inspiration and expansion of the chest wall caused diminution in size of the air pocket on the anterior chest wall. With forced expiration of air the chest was contracted, the external pressure relaxed, and the air pocket in the anterior chest wall bulged. The area of interstitial emphysema seen in the soft tissues of both necks, the anterior chest wall, and the abdomen had considerably diminished since the first examination. It was difficult to

establish the communication between the pockets of air in the chest wall and the pneumothorax.

Summary.—Diminution of interstitial emphysema; large hydropneumothorax; localized pocket of air and fluid on the right anterior chest wall in the region of the second and third ribs; pocket of air and fluid behind the midportion of the gladiolus (Figs. 3, 4, 5 and 6).

X-ray Examination.—Nov. 2, 1931. There was an increase in the homogeneous shadow of the right chest from the second anterior rib to the base, obscuring the diaphragm, lower ribs, and costophrenic angle. The amount of the pneumothorax in the pleural cavity had diminished although there was an increase in the amount of fluid in the chest. The pocket of air beneath the right clavicle on the anterior chest wall had considerably diminished and was seen along the anterior wall of the chest. The pocket of air behind the sternum was likewise considerably smaller.

Summary.—Increased right pyopneumothorax; interstitial emphysema along the anterior chest wall (Figs. 7, 8, 9 and 10).

As a result of this report, the patient was sent to the operating room on November 4 for thoracotomy. He expectorated a considerable quantity of purulent material while on the table. Because aspiration through the sixth, seventh, and eighth intercostal spaces in the posterior axillary line proved negative and percussion resonance seemed better than the roentgenogram indicated, the operation was discontinued.

The temperature gradually subsided and the general condition and cough became much better. On November 11 the patient left the hospital in good general condition. His temperature was 99, pulse 110, and respirations, 20.

X-ray Examination.—Nov. 24, 1931. Re-examination revealed a complete absorp-

tion of fluid in the right pleural cavity with almost complete expansion of the entire right lung with the exception of the right base. The diaphragm here was still elevated but showed a fairly good excursion, al-

pansion of the right lung; residual pathology at the right base with thickened pleura (Fig. 11).

Physical examination at this time revealed a good respiratory sound and reso-

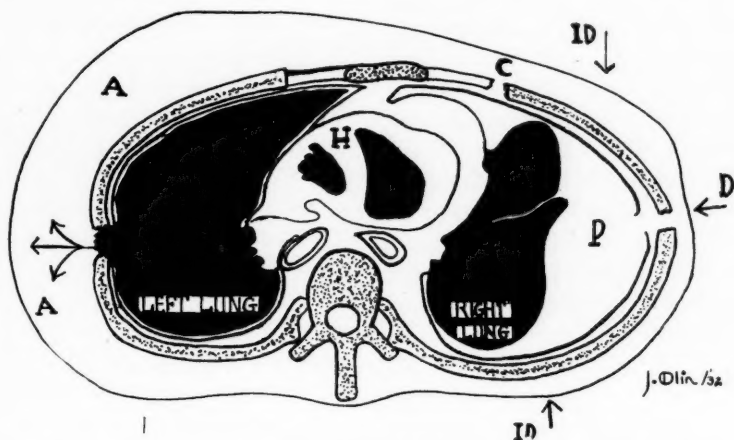


Fig. 12. Diagrammatic cross-section of thorax to show the mode of production of pneumothorax or hemothorax and of subcutaneous emphysema as a result of fracture of the ribs. ID—The arrow shows the line of application of indirect force in producing fracture of the ribs. D—Line of application of direct force in producing fracture of the ribs. P—pneumothorax as a result of fracture of the ribs and laceration of the pleura on the right side. A—extensive subcutaneous emphysema as a result of puncture of a lung by the sharp ends of a fractured rib fragment. The triple arrow shows the mode of egress of the air from the punctured lung into the subcutaneous tissues. H—cross-section of the heart. C—fracture at costochondral junction without displacement.

From Keen's Surgery, Vol. II, p. 159.

though not so deep as on the left. The several pockets of air and fluid which had been seen on the previous examinations had disappeared. In the right chest there was still some irregular mottling at the base, residual of the infection, associated with thickened pleura. The markings as a whole were accentuated, with a band of thickened pleura seen in the third right anterior interspace. The trachea and heart were in normal positions, but the mediastinal shadows showed definite root thickening, undoubtedly associated with the previous pyopneumothorax.

Summary.—Obliteration of several pockets of air and fluid; complete absorption of interstitial emphysema; restoration of ex-

nance down to the region of the sixth rib in the axillary line and the eighth rib in the posterior scapular line. The patient coughed rarely. He had been going out of doors for a week, his appetite was good, and his general strength was returning. When he was seen last on November 30, he had no complaints. He was sent back to resume work.

Binney is of the opinion that lung injury by sudden pressure or rupture by the sharp end of a fractured rib will usually cause hemoptysis and some degree of pneumothorax, hemothorax, or both. If pneumothorax is present, sooner or later signs of cutaneous emphysema of the chest wall may appear (37).

DISCUSSION

The noteworthy feature in this case was the presence of a protruding mass or bulging of the anterior chest wall, the size of a baseball, in the region of the second and third ribs. The mechanism of such a crushing injury is interesting and one is puzzled to learn the extent of damage to the thoracic viscera. The presence of a bronchial fistula was demonstrated by hemoptysis from the third to the fifteenth day until it gradually subsided, associated with attacks of a violent, persisting cough and the expectoration of sticky, yellow, tenacious material. The fistula and the bulging chest mass gave proof of the presence of an open pneumothorax and a hemothorax. Emphysema of the skin or evidences of hemo- or pneumothorax are positive signs of a fracture of the ribs (38). The multiple fracture of the ribs evidently tore the lungs and pleura to such an extent as to cause hemorrhage into the pleural cavity, allowing the escape of air from the injured lung into the subcutaneous tissues of the right and left neck, chest wall, and abdomen. After a lapse of six or seven days, the hemorrhage ceased and the rent in the lungs became sealed with pleural exudate. With laceration of the soft tissues of the anterior chest wall, the pleura, covered only by skin and a thin layer of superficial fascia, protruded through the opening in the chest wall.

At about the end of the third week I observed the exact location of the bulging mass and the effect upon respiration. (I previously had examined the patient several times under the fluoroscope and had made plates in various positions on each occasion.) Palpation revealed a distinct hollow in the second rib, due to loss of tissue. With inspiration, the mass became smaller; after expiration it bulged outwards, and was the size of a small orange. Fluid was easily detected in the bulging mass. The contents seemed to be a viscid, sticky material and compressed, crepitant tissue.

I am not able to determine how long the lung punctured by a broken rib may pump air with every respiration into the tissues, although fifteen days after the accident the emphysematous air was slowly being absorbed and considerably less was present than on the day of admission. Since this mass was visibly affected by respiration, the pertinent question arises: what were the layers of tissue comprising this mass? That this external chest wall pocket communicated with the pleural cavity is evident from the nature of the phenomena occurring during respiration. One attempt at solution would explain this pocket as a purely external cavity filled with air and fluid. During the height of a full inspiration with the lungs completely expanded and the thoracic cage increased in volume to accommodate the increased lung volume, the external chest wall pressure would be sufficient to compress the pocket. Conversely, at the height of a full expiration, the full compression of the thoracic cage and its contents would permit complete relaxation upon the cavity, which would cause it to bulge. This mechanism is fully brought out by Figure 12 and is applicable to the cause and formation of subcutaneous emphysema and pneumothorax complicating rib fracture. On inspiration, the lung expands and air rushes into the pleural cavity; on expiration the lung collapses and the rent in the lung tissue is closed so that withdrawal of air from the pleural cavity becomes impossible. This phenomenon probably occurred within from seven to ten days following the accident. That the mass connected with the pleural cavity is obvious, in that respiration changed its form and size. If no communication of the pocket existed with the pleura, no expansion and retraction would occur other than moderate tension of an expanded chest against the wall of the cavity.

With pyopneumothorax present, the bulge essentially amounted to a hernia of the lung. According to most text-books, hernia of the

lung occurs most commonly anterolaterally in the chest, and there may or may not be a layer of parietal pleura. In cases of long standing, because of the adhesions to the overlying tissues, the hernia may be irreducible. The hernial sac under discussion, however, was readily reduced and held in place by a circular cardboard over its orifice. Lilienthal claims that in true hernia only a small amount of lung extrudes and strangulation rarely happens as the lung tissue is so easily compressible (32). To quote further: "There is a tendency for the tumor to decrease in size during *inspiration* and sometimes to protrude with ordinary *expiration*; cough will cause the tumor to become tense." This author, quoting from Sauerbruch, states that, if the reverse phenomenon occurs—bulging on inspiration and retraction on expiration—a complication of diaphragmatic injury with prolapse of abdominal viscera into the thorax and out through the chest wall may be suspected.

SUMMARY

A severe crushing injury of the chest complicated by lung hernia, three fluid level pockets, pyopneumothorax, and extensive subcutaneous emphysema of the chest wall and abdomen resulted in apparent recovery, full re-expansion of the lung, and closing of the hernial sac without operation. The withdrawal of 915 c.c. of pus, followed by replacement with an equal amount of air, and expectant treatment, were sufficient to alleviate fully the condition in seven weeks following the extensive injury.

Since this writing, we have received word that the bulging in the chest wall has recurred, although the patient is attending daily to his duties as an automobile mechanic. He has promised to pay a visit to his physician but has not reported up to the present time (March 15, 1932).¹

¹Patient was seen again in June and appeared in good health. The bulging mass had disappeared entirely and the chest, other than the thickened pleura at the right base, appeared normal.

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THE TERMINAL ILEUM, CECUM, AND ASCENDING COLON FROM THE STANDPOINT OF THE ROENTGENOLOGIST¹

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THIS discussion is based on findings in 10,000 colon fluoroscopies, studied with the clinicians at Presbyterian Hospital and Rush Medical College. It is my good fortune in x-ray work to be very closely associated with the clinicians. Seldom is a fluoroscopy done without the presence of the patient's attending physician, his interne, and often medical students. In case the physician cannot be present, he communicates with the roentgenologist. We study the fluoroscopy and films together and discuss the pros and cons of the x-ray findings in the light of the patient's clinical condition. This arrangement has been of inestimable value to patient and doctor.

PREPARATION OF PATIENT FOR COLON EXAMINATION

The psychologic preparation of the patient should be stressed. A few words of explanation and assurance given to patients, particularly to those who are apprehensive, before they enter the dark room, help a great deal. The patients relax better and are easier to examine.

We like to have the bowel emptied by the use of one or two one-quart enemas. Not less than two hours should elapse after the last enema before the fluoroscopy. If the patient has diarrhea, no preparation is needed. Medication which irritates the bowel produces spasm and may lead to a faulty diagnosis. Proctoscopy should not be done less than two hours previous to fluoroscopy, because of the air that enters the bowel and the relaxation of the anal sphincter which occurs.

TECHNIC

A barium enema, composed of one part of barium sulphate to three parts of water warmed to body temperature, and well stirred, is the usual contrast medium employed in x-ray examination of the colon. The enema can be placed three feet above the patient; the flow is regulated by a bulldog clamp on a soft rubber tube leading to a sterilized hard rubber enema tip, three inches long. The air is expelled from the hose. We tell the patient, "We are going to give an enema which we can watch as it goes in. If it causes pain, tell us, and we will stop it."

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We first fluoroscope the chest and abdomen. The enema is then injected slowly, under fluoroscopic control, until the colon is filled, or until the patient complains of pain. If there is pain, we stop the enema or decrease the flow by compression of the tube, and tell the patient to take deep breaths. As the pain subsides, we continue the enema, and so on, until barium passes into the small bowel, which is our signal that the colon is completely filled. If the pain does not subside or barium does not progress, we stop the injection. Except in cases with an obstructive process, the colon can usually be filled by a little persistence and without much difficulty or distress to the patient. As the colon fills, we turn the patient to left and right and palpate the abdomen in order to visualize all parts of the colon, to uncover or straighten out redundant loops, to test the mobility and pliability of the bowel, and to elicit any areas of tenderness. If there is pain, we try to determine if the patient's typical distress is reproduced; if it is localized to the colon, or is increased by the enema or by palpation. Any palpable masses are studied in their relationship to the bowel. We always look for an appendix and palpate in this region for tenderness.

Occasionally the examination is by means of a barium meal followed through the small bowel and colon by repeated fluoroscopic examinations. This method of examination is dangerous if the patient has clinical signs of obstruction. In this case, the patient should be carefully watched and given mineral oil by mouth, and enemas as necessary. Drastic cathartics or irritating enemas should never be given.

NORMALS AND VARIATIONS OF NORMAL

Normally the barium enema passes readily into the colon and fills it uniformly and completely, with little or no pain to the patient. Moderate haustral indentations are visible along the bowel margin, except in the

rectum. In my experience, barium passes into the terminal ileum in nearly all cases in which the cecum can be filled. Occasionally, with the colon well filled, no barium passes into the small bowel. This finding should be checked by barium from above. If nothing else is found to account for it, either roentgenologically or clinically, then the fact of valve competency is of no significance.

During fluoroscopy, one sees many variations in length, redundancy, and position of the colon, as a whole or in part, even to complete transposition (*situs inversus*).

Ptoxis of the colon, as that of the stomach, may be so marked, especially in thin women, that the greater part of the colon appears to lie within the bony pelvis, which is normal for that type of individual; or the colon normally may extend to or above the costal margin in the short, heavy-set type of individual.

The capacity of the colon normally varies considerably in different patients. For example, from one to four quarts of fluid is required to fill the bowel, the average capacity being about one and a half quarts.

These are anomalies, depending either upon incomplete embryonic descent and rotation of the hindgut, or upon the habitus of the patient. Human beings vary as much on the inside as they do on the outside and many variations exist which are well within the range of normal.

Of course, malpositions which are pathologic may occur: for example, the projection of a loop of bowel into a hernial pouch, or displacement by extrinsic pressure, as from a large liver or spleen, a big kidney, a mesenteric or ovarian cyst, a large fibroid or a pregnant uterus, enlarged mesenteric glands, etc.

Although pathologic variation in size or position, occurring from adhesions, membranes, bands, or kinks, is fortunately not common, when present, it is of great significance. In my experience, if the colon

fills to normal size and has a reasonable range of mobility, that is, from two to three inches, it has no significant adhesions. Any apparent angulation of the colon, which looks like a sharp kink, particularly if an air bubble is present, should be examined by turning the patient, or by manipulation. By this means, it is often shown to be only a curved segment of normal sized bowel.

COLON PATHOLOGY

In this discussion of pathologic changes I shall omit the x-ray diagnosis of appendicitis since it is being discussed by another.

Probably the lesion most easily recognized by means of the barium enema is the "napkin-ring constriction" of the lumen or the irregular filling defect so characteristic of carcinoma. The area of the deformity corresponds closely to the size of the tumor. After the sigmoid, the cecum is the most common site of carcinoma of the colon, although any part of the bowel may be involved.

Case 1. A patient had a filling defect about two inches long in the upper end of the ascending colon near the hepatic flexure. On the first examination the colon filled normally up to that point; then the patient had great difficulty in retaining the enema and the barium did not penetrate further. Two days later, on re-check examination, barium passed through the area of constriction, filled the cecum, and some passed into the small bowel. The area of napkin-ring deformity did not fill. In addition to this constriction, there was considerable spasm associated with the lesion. One of the films showed most of the barium cramped out of the transverse colon, while on another film this region was well filled. Both films recorded the constricting defect. There was a tender, palpable mass at the site of the constriction. The clinician stated that the patient had been losing weight and that blood was found in all stools examined. Considering the type of filling defect and the pa-

tient's history, carcinoma seemed the most probable diagnosis. This was confirmed at operation.

Case 2. Clinically the lesion of this patient was diagnosed as carcinoma of the colon. Prior to surgery, the patient was referred to the roentgenologist for the exact localization of the lesion. The barium enema entered the bowel readily, filled the rectum and rectosigmoid normally, and then passed through an irregular constriction of the sigmoid 3 inches long. Beyond this the rest of the colon filled to a little larger than normal size to the upper part of the ascending colon, where it stopped completely. The margin of this obstruction was irregular and somewhat pointed at each edge. I wondered if this patient could possibly have two carcinomas in the colon, since both defects resembled those frequently seen in carcinoma. The operation showed a large, definite, annular carcinoma at the site of the defect in the ascending colon. Gravitation metastases produced a compression deformity of the sigmoid colon, which, when freed from this mass, appeared normal.

Sometimes the filling defect of carcinoma is not easily recognized either fluoroscopically or on a film, particularly if it is an early lesion and of small size.

Case 3. On fluoroscopy of another patient the colon filled well, except that no barium passed the ileocecal valve and the mesial margin of the cecum was somewhat concave. Barium given by mouth passed readily through the small bowel and colon in normal time. However, there was an irregularity of the barium outline in the cecum at the ileocecal junction and the terminal inch of the ileum was narrowed. On reviewing films made elsewhere a year previously, this same deformity was visible, except that it was smaller and a little less definite. In the year's interval, the patient's attacks of pain had continued and had gradually become worse. The presence of a mass the size of a walnut in the right

lower quadrant and the rhythmic character of the pain, which suggested a small bowel obstruction, were the clinician's reasons for requesting an x-ray study of the colon. The fact that the same defect was present on films made on two examinations a year apart was very significant, and, together with the history, led to the diagnosis of carcinoma. This was confirmed at operation, the cecum resected, and a lateral anastomosis done.

A year post-operatively, barium passed readily into the small bowel at the site of the anastomosis. This fact calls our attention to deformities of the bowel, which, when seen fluoroscopically, should lead the roentgenologist to inquire as to any previous operations.

Case 4. The patient's colon filled readily to normal size throughout. Barium passed the ileocecal valve to fill and distend the terminal inch of the ileum, and then stopped abruptly, with a somewhat irregular contour. The film showed, in addition to the defect, two air-filled, distended loops of small bowel. These findings, which speak for an obstructive process in the terminal ileum, closely resemble the findings of Case 3. The history revealed, however, that this patient was operated upon five years earlier for carcinoma of the uterus, that she had been symptom-free until recently when she began to have pain and distention in the abdomen, and, in the last few days before the present examination, definite signs of intestinal obstruction. Carcinomatosis was found at operation, with many nodules in the mesentery and peritoneum. Several loops of small bowel were adherent to the anterior abdominal wall. A band of adhesions as thick as a finger closely bound the terminal ileum, producing obstruction and the defect which was seen roentgenologically. This band was severed and drainage established. The patient died 10 days later.

Case 5. The patient, a diabetic, was roentgenographed because of pain in the right lower quadrant, associated with a

palpable mass and an elevation of temperature. Extensive tuberculosis of the left lung was evident on a film taken six years previously. Formerly there had been many tubercle bacilli in the sputum, though recently the chest condition had seemed less active, clinically.

Fluoroscopically, the barium enema filled the colon readily to good size throughout. The transverse colon was long and redundant, the cecum markedly spastic. No barium entered the small bowel. There was extreme tenderness over the cecum.

On re-check a few days later, after the pain had somewhat subsided, a barium meal passed through the small bowel and colon in normal time. There was a small area in the cecum, near the ileocecal valve, which did not fill well. Palpation gave the impression that it was caused by a mass posterior to the cecum. This finding remained constant and corresponded to the findings noted during the previous fluoroscopy. The film taken after the barium enema showed a curved depression on the mesial side of the cecum.

A tender spastic cecum, in a patient with known pulmonary tuberculosis of rather long standing, spoke strongly for a tuberculous bowel. An associated mass suggested tuberculous glands in the mesentery or peritoneum. Against this diagnosis was the rather sudden onset of symptoms, exquisite tenderness, and the fact that the mass was apparently single and fairly large and globular, instead of the multiple, firm, tender nodules usually found in tuberculous glands.

A few days later the mass disappeared spontaneously, and the patient's pain and temperature subsided. The clinician's diagnosis was then ovarian cyst, probably a corpus luteum cyst, which had ruptured.

Case 6. The x-ray film and the fluoroscopic findings of the right side of the colon of this patient were almost duplicates of those in Case 5. The palpable mass in the abdomen was irregular and only moderately tender. Small firm nodules were pal-

pable in the neck, axillæ, and groins. His chest film was negative for tuberculosis. The hilus shadows were heavy and somewhat nodular in outline, very suggestive of enlarged glands. This 53-year-old man was weak, anemic, and had lost 15 pounds in weight in the six weeks preceding this examination.

When the x-ray findings of the colon and chest were associated with the clinical evidence, we could rule out both tuberculosis and cancer, and diagnose lymphosarcoma. X-ray treatment helped temporarily, though not for long. As a terminal condition, both ureters became occluded by the abdominal mass. The diagnosis of lymphosarcoma was confirmed both by section of a gland and by postmortem examination.

SPASM

Spasm, or intermittent contraction and relaxation of the colon, may be sufficient to cramp all the barium out of a large segment of the bowel. It is usually accompanied by considerable pain and marked desire to go to stool. In the intervals of relaxation, the bowel fills to normal size. Barium usually passes into the small bowel somewhat in proportion to the degree of spasm.

Spasm of the right side of the colon may be a part of the generalized spasticity of a functionally irritable colon, or a toxic colitis. Occasionally the spasm occurs in attacks with pain so severe as to necessitate morphine for relief, and so localized as to simulate appendicitis or a kidney or gallstone colic. If, however, the patient's typical pain can be reproduced by filling the bowel, and we see fluoroscopically that the site of the pain is in the position of the colon, and does not correspond exactly to the suspected area (kidney, gall bladder, etc.), if the genitourinary and gall-bladder films are negative, and the history is that of a bowel disturbance, we have come a long way toward establishing the diagnosis. On the other hand,

spasm may occur only, or chiefly, on the right side of the colon, due to intrinsic causes, the most usual being tuberculosis or amebic dysentery. Likewise, spasm may occur reflexly from extrinsic causes, such as an inflammatory process of the appendix, gall bladder, or kidney, a pelvic or psoas abscess, pyosalpingitis, or similar conditions. The differentiation may be difficult, although a correct diagnosis may usually be established by consideration of the history, all the clinical and physical findings, and the x-ray evidence.

Case 7. In one case, localized spasm simulated the napkin-ring deformity of carcinoma. The rest of the colon filled well, but neither by palpation, turning the patient, having her take deep breaths, nor by introducing more barium, could I change the aspect of this deformity. The area was only moderately tender and no mass was palpable. Clinically no evidence suggesting carcinoma had been found. Both the attending physician and I were at a loss to explain this finding. We thought the fluoroscopy should be re-checked and the clinical evidence reviewed for possible carcinoma. Two days later, the examination of the colon showed no evidence of this constriction.

Case 8. The patient was a healthy looking man, 50 years old, who complained of intermittent diarrhea of five years' duration. The barium enema filled his colon readily to good size up to the ascending portion, at which point intermittent spasm was seen, although there was none elsewhere. The patient experienced moderate distress from the enema. The film showed a definite, irregular constriction of the cecum and lower part of the ascending colon, suggestive of carcinoma. Fluoroscopically, carcinoma was easily ruled out because of the intermittent filling and emptying and the absence of a palpable mass. The proctoscopic examination revealed ulceration in the lower bowel and the stools contained motile amebæ.

Case 9. In another case, the colon fluoroscopy showed only spasm, yet it helped to settle the diagnosis. While in the country, a boy of 8 years had had an acute attack of right abdominal pain, with high temperature and vomiting, associated with rigidity and tenderness in the right lower quadrant. A local physician very logically diagnosed appendicitis, and advised immediate operation. The parents, however, remembered several similar previous attacks and hurriedly took the boy to their home physician. The boy was placed in the hospital, and, after a few days of rest, plenty of fluids, some alkalis, and a light diet, the attack subsided. In the meantime the colon was fluoroscoped and found negative except for slight spasm, mostly on the right side, and some tenderness of the bowel on pressure. The site of the recent pain did not correspond exactly with the position of the appendix, which was well filled and easily movable. This ruled out appendicitis. With the favorable response to treatment, the pediatrician's diagnosis of allergic reaction of the bowel was confirmed.

EXTENSIVE NARROWING OF LUMEN:
ULCERATIVE COLITIS

Case 10. Here is a case, first examined in 1925, in which the diagnosis can be made with a considerable degree of certainty from the x-ray examination alone. The descending colon and the distal portion of the bowel filled as a narrow channel an inch in width. There was little evidence of haustral markings. The proximal portion of the transverse and the ascending colon filled to normal size. The patient complained of only moderately severe distress from the enema. The film confirmed the fluoroscopic findings and was quite characteristic for an ulcerative colitis. That diagnosis also fitted the clinical evidence of pus and blood in the stool and ulcers in the lower bowel, visible proctoscopically.

In spite of treatment, including colostomy, the condition persisted and progressed. A film made in 1928 showed marked narrowing of the transverse and descending portions, with a fair filling of the ascending colon. In June, 1931, the colon filled almost as soon as the enema was started, and a considerable amount of barium came out through the colostomy. Barium entered the small bowel also. The film made at that time showed the lumen of the colon to be about the size of a drinking straw throughout and very much shortened. Clinically, the patient was comfortable, and wanted her colostomy repaired. Needless to say, this was not done.

Sometimes there are one or more groups of small, rounded areas of decreased density in the barium filling which resemble small polypoid projections into the lumen of the bowel. This condition is due to a papillary hyperplasia of the mucous membrane of the colon, which develops in the region of a chronic inflammation in the bowel wall. This condition, which may be extensive or localized, is a complication of ulcerative colitis.

Case 11. In this patient, the condition, which was present throughout the transverse and descending portions of the colon, was associated with a marked ulcerative colitis. We were unable to fill the bowel completely because of severe pain and spasm. An outstanding clinical feature of this case was repeated attacks of severe bowel hemorrhage.

Case 12. Another patient's condition clinically strongly simulated a carcinoma. He became severely emaciated, weak, and anemic, and there were pus and blood in the stool. A single group of multiple round areas of decreased density were seen in the lumen of the descending colon, serving to differentiate the lesion from carcinoma and establish the x-ray diagnosis of localized papillary hyperplasia. The rest of the bowel filled to somewhat larger than normal size,

with a smooth lumen somewhat lacking in haustral indentations. The postmortem diagnosis was localized papillary hyperplasia in conjunction with ulcerative colitis.

LESIONS WITHIN THE LUMEN: POLYPS

Sometimes one finds a single rounded or slightly loculated filling defect in the lumen of the bowel, which suggests an air bubble or a fecal mass. The bowel fills well and is pliable except that this same air-bubble type of defect is reproduced each time pressure is made in that region, or it is seen without palpation, if it is large enough. In the event that these findings persist on re-check examination after enemas, the diagnosis of a polyp is practically certain.

The clinician is usually searching for a source of unexplained, persistent, or intermittent blood in the stool. There may be little or no distress. A mass may be palpable, or only questionable, or not found until after it is localized by x-ray examination.

Case 13. A polyp is usually localized to a certain area; in one case, however, it could be pushed along from the cecum to the hepatic flexure. Each time we worked it up to the hepatic region, it slipped away and fell back to the cecum. At operation, there was found a polyp on a very long pedicle attached close to the ileocecal valve. A large polyp located in the cecum may prevent the reflux of barium into the small bowel.

INTUSSUSCEPTION

In cases of intussusception, the bowel fills normally except that, in the cecal region, the barium appears to be displaced by a large air bubble which prevents the enema from entering the small bowel. This spurious air bubble, which is due to the invagination of the terminal ileum into the cecum, varies in size with the degree of invagination. The defect is persistent unless one is fortunate enough to reduce the intussusception by

manipulation, in which case the x-ray findings return to normal.

A large polyp in the cecum and intussusception look remarkably alike roentgenologically, and may be confused. With intussusception, however, there is usually an acute, prostrating pain in the right lower quadrant, which remarkably simulates appendicitis. Intussusception is most often seen in children, although both types of lesions may occur in either children or adults.

DILATATION OF BOWEL LUMEN

Sometimes the lumen of the large bowel is dilated to several times its normal size, either in some segment of the bowel, or through its entire extent. Such a dilatation occurs in the congenital idiopathic condition known as megacolon, or Hirschsprung's disease. In the localized type, the dilatation, which roentgenologically is usually an abrupt change from the normal size, is most often in the left or distal portion of the colon. Barium is usually retained in this segment after it is evacuated from the rest of the bowel. In very severe grades of this disease the dilatation may involve the entire large bowel.

The dilatation of an atonic bowel, such as is sometimes seen in aged or debilitated patients, or those addicted to the enema habit excessively, is not, as a rule, so marked as in megacolon. Although generalized, the dilatation is more pronounced in the proximal part of the colon, especially the cecum and ascending colon. The bowel usually will empty fairly well. The normally large bowel, sometimes seen even in children, usually has good muscle tone and will empty readily. In each case the history and clinical findings are of importance in establishing a correct diagnosis.

Case 14. The patient, a young man, stated that his bowel movements had been infrequent since childhood, and that for several years preceding the present examina-

tion, he had taken an enema of 10 quarts of water about once a week, and had thus succeeded in obtaining a bowel movement. His original film was a 10×12 one, and, therefore, the diameter of this air-filled segment of the bowel shown on it must have been at least eight inches.

LESIONS PROJECTING BEYOND BOWEL MARGIN: DIVERTICULA

Occasionally, on filling the bowel of a patient 40 years old or over, a small round shadow projects beyond the bowel margin, either with or without a pedicle. Its size may vary from that of a pinhead up to 2 cm., rarely more. It is a diverticulum. Diverticula, which are usually multiple, are most often located in the sigmoid, or are more numerous there if they extend to other parts of the bowel. Occasionally, diverticula are limited to the right half of the colon, or a single diverticulum may be present near the hepatic flexure. Diverticula often remain filled with the opaque material for a considerable time after it passes out of the rest of the bowel. This may lead to confusion, and necessitate differentiation from other conditions, such as barium retained in contracted haustra, stones in the gall bladder or urinary tract, phleboliths, or calcification of mesenteric glands, psoas abscess, fibroids, or ovary. The differentiation is usually made by filling the bowel, visualizing the diverticulum, and pushing it away from the area in question.

INFREQUENT OR UNUSUAL CONDITIONS

One must always be on the lookout for rare or unusual conditions. Foreign bodies are sometimes a cause of abdominal pain or of obstructive symptoms, especially in children, since they are so apt to swallow coins, small toys, etc. Adults sometimes swallow a foreign body or, unfortunately, a foreign body may be left in the abdomen

at operation, or introduced at the time of an injury, such as an automobile accident.

The pain of pneumonia, especially in children, may be referred to the right side; it may simulate appendicitis, or gall-bladder or kidney-stone colic, or, more rarely, some other intra-abdominal condition. A chest film should not be forgotten; it will help wonderfully in clearing the diagnosis.

Lesions in a right-sided sigmoid, or an anomalous position of the cecum, may cause much confusion of the clinical picture. This is easily cleared up by a colon fluoroscopy.

THE USE OF THE COLON EXAMINATION IN DIFFERENTIAL DIAGNOSIS

A colon fluoroscopy often aids in the diagnosis of lesions outside of the bowel.

Case 15. A film of the patient's genito-urinary tract showed a small dense shadow in the line of the right ureter. This shadow was unusually round for a urinary stone, and not quite uniformly dense. A colon fluoroscopy showed multiple diverticula, one of which corresponded exactly to the position of the small shadow in question. We found that stomach fluoroscopy had been done two months previously, and that a film of the abdomen, taken prior to the stomach examination, did not show the shadow in question. Evidently this shadow was due to barium retained in a small diverticulum for a period of two months.

Case 16. A patient came to the hospital with urinary bleeding and a large, nodular, slightly tender mass in the right upper quadrant. What was the mass? Fluoroscopy of the colon showed that the hepatic flexure was markedly displaced downward and forward. Firm, rather deep, pressure was needed before the barium in the colon was displaced by compression against the mass. This spoke for kidney enlargement. A compression defect of the barium is obtained by very light palpation in the case of liver

enlargement, because of its more anterior location. Bilateral pyelograms showed an irregular, bizarre filling of the right and a somewhat enlarged left, although the latter might almost be considered within the range of normal. The right pyelogram indicated a polycystic kidney, but, since the left side did not show a similar type of deformity, tumor could not be ruled out in the face of the urinary bleeding. Therefore, the patient was explored. The condition proved to be a bilateral congenital polycystic kidney, which, of course, saved the right kidney from removal.

Case 17. This patient's cystogram showed two large rounded shadows in the lower abdomen, one anterior, trabeculated, and evidently the bladder, the other posterior, smooth-margined, and larger than the bladder shadow. The differentiation between an unusually large diverticulum of the bladder and a rectovesical fistula, through which the solution had passed into the colon, was necessary. A colon fluoroscopy in conjunction with the cystogram showed the colon separate from either of the rounded shadows in question. This enormous bladder diverticulum was later removed.

Case 18. A female patient, 55 years of age, complained of severe pain in the pelvis and right leg. A hard mass was palpable on the right side of the pelvis, extending upward higher than the finger could reach, and apparently fixed to the bone. A film of the pelvis showed bone destruction in the right ischium and the inferior ramus of the pubis. A colon fluoroscopy demonstrated that this tumor (inoperable) did not arise from the large bowel. Biopsy sections showed it to be a small round-cell sarcoma. Treatment by radium and x-ray was given, the bone recalcified, and the patient is still living and well, now nine years later.

Case 19. A middle aged, very heavy woman was brought to the hospital with severe colicky pain in the right upper quad-

rant, strongly suggesting gall-bladder disease. On the plain film there was seen a large annular shadow high on the right side in the gall-bladder position, more sharply defined on the postero-anterior view. In my opinion, it was undoubtedly a gallstone. Cholecystography was not done. At operation, a small contracted gall bladder, bedded in dense adhesions, was found and removed. It contained *no stone*, and the surgeon felt no calcareous mass in this vicinity.

The shadow in question was so typical for a gallstone that I asked permission to examine the patient again. Three days after the operation, the patient, who had been doing nicely, began to have gas distention of the abdomen to such a degree that intestinal obstruction of high grade was evident. The surgeon requested a colon fluoroscopy to locate the site of obstruction, but I suggested a plain film of the abdomen first. This showed that the same annular shadow was now located in the right lower quadrant and that there was an enormous gas distention of the small bowel.

Now it was easy to reconstruct the history. After perforation by a stone the size of an English walnut, the gall bladder had contracted to the size of a man's thumb. The operative manipulation freed the stone from its bed of adhesions, which were so dense that the stone was not felt; in the three-day interval it had progressed to the terminal ileum, and was blocked by the ileocecal valve. The intestinal obstruction was relieved, and the diagnosis confirmed by the removal of the stone.

SUMMARY

With the exception of surgery, the x-ray is the only means to determine the exact position, size, and configuration of the terminal ileum, cecum, and ascending colon. With the aid of the x-ray, it is easy to say whether there is a constant filling defect, as in carcinoma, or one which is intermittent, as in spasm; whether there is a projecting

deformity, as a diverticulum, an infringement upon the lumen from a lesion within it, as from a polyp or intussusception, or a compression deformity from an extrinsic mass. These conditions may be difficult or impossible to determine clinically.

The x-ray is of great value as confirmatory evidence, and to determine the exact size and position of lesions which may be diagnosed clinically. Carcinoma and ulcerative colitis are outstanding examples.

There is also a large group of cases in which the diagnosis is inconclusive either from the roentgenologic or clinical evidence alone, but which may be correctly diagnosed by close association of both types of evidence; for example, whether spasm is due to intrinsic, extrinsic, or reflex causes; the reason for compression deformities, etc.

Close co-operation between the roentgenologist and the clinician insures the best result for the patient.

BILATERAL DIAPHRAGMATIC HERNIA¹

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THE ever increasing number of publications on diaphragmatic hernia is evidence that the condition is not so rare as has been thought heretofore. In the pre-roentgen era, a hernia of the diaphragm was seldom diagnosed as such while the patient was alive. The first two cases, which Ambroise Paré described in 1610, were found at autopsy. In 1790, two others were reported by Petit, one of eventration and one of hernia. In 1829, Curveilliers distinguished between congenital and acquired diaphragmatic hernia. The hernia may be true or false, depending upon whether or not its contents are wrapped in a peritoneal sac. Of the 635 cases gathered by Eppinger, in 1911, from the entire literature, only a few were diagnosed during the life of the patient. Gradually the roentgen examination took first place in the diagnosis. In 1924, Moore and Kirklin estimated the number of described cases at 1,200. Up to this time only 20 cases had been diagnosed at the Mayo Clinic, a number which, six years later, had increased to 110. Similar reports are made by Healy, Morrison, Akerlund, Hedblom, LeWald, and many others.

While Quenu, in 1921, considered the hernia at the hiatus esophagi as extremely rare, Moore and Kirklin, Akerlund, Morrison, Ritvo and others found this to be the most common type. Other sites at which a hernia may occur are the trigonum costosternal (foramen Morgagni), the trigonum costolumbale (foramen Bockdalecki), the foramen quadrilaterum, and the foramen nervi sympatici. It is more common on the left than on the right side. Of the 635 cases reported by Eppinger, only nine were on the right side. It appears that the large bloc of the liver prevents the formation of a hernia. However, Reich, in three of his cases, has shown that parts of the liver may form the contents of a diaphragmatic hernia. More frequently, the sac of a hernia contains stomach, intestines, omentum, or a combination of these. The sac may be small and may, in certain positions of the patient, reduce itself automatically. It may be found only by placing the patient in certain positions. However, it may reach large dimensions and fill the entire side of the chest.

The parasternal type of congenital diaphragmatic hernia is very rare. Woolsey found one case of hernia of the left, and Siehlmann one case of the right, foramen

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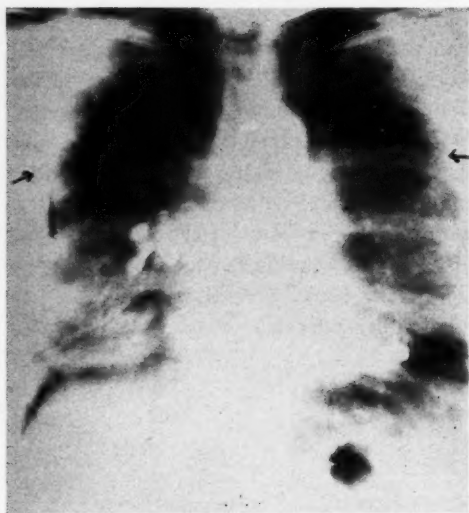


Fig. 1. The upper margins of the hernias, which are separated by the mediastinum, are marked by arrows. To the right of the heart, as well as to the left, traces of barium and gas in the bowels may be seen. Notice the gas bubble in the cardiac portion of the stomach. The diaphragm is distinct on both sides.

Morgagni. Hedblom gathered six cases. All these, as well as all cases of diaphragmatic hernia heretofore described, have been unilateral. There is no case of bilateral hernia of the diaphragm previously described in the literature.

CASE REPORT

Miss McG—, aged 60 years, a business woman. Since the onset of her periods, the patient had suffered from dysmenorrhea. Up to 1912, she had never been sick or had any injury or accident, but in that year she was operated on for a huge uterine fibroid, which weighed 28 pounds. Before, and after this, she passed three examinations for life insurance. After the operation, she began to complain of continuous gas pains and of occasional severe attacks of cramps in the abdomen and chest, whenever the bowels became only slightly constipated, and a gradually increasing shortness of breath, with a sense of exhaustion after the least exercise. Bending forward was an especially great ef-

fort for her. By keeping the bowels in good condition and avoiding exercise, she managed to keep comfortable and to pursue her vocation. One of her occasional attacks brought her to her physician, who sent her to St. Mary's Hospital to be roentgenographed.

Examination revealed a well nourished patient, white, weight 175 pounds, blood pressure 162/98. There was no cyanosis. The chest expansion was from 40.5 to 41.5 inches. There was a slight venous marking in the region of the sternum. At the third rib anteriorly on the left side, the normal sounds of the lung changed to flatness. The same condition was found on the right side, beginning 0.5 inch lower. Posteriorly, the normal sounds extended to the eleventh rib on the left side and to the tenth rib on the right. Auscultation revealed normal breathing on both sides down to the fourth rib anteriorly, and over the entire lung fields posteriorly. Sounds of regurgitation could be heard over the areas of flatness, especially when the patient changed her position. The heart sounds were normal. The heart borders could not be outlined, nor the apex beat felt. The abdomen was soft and not distended. A scar extended from the navel to the symphysis. The liver was soft; its edge, which was felt about one inch below the costal margin, moved readily with respiration. There was pronounced tenderness in the entire epigastric region.

Under the fluoroscope the upper lung fields appeared clear. From the third rib down, a shadow which occupied the anterior part of the chest and included the heart, was superimposed upon both lung shadows. Its upper margin, which was very distinct, moved slightly with respiration. Posteriorly it was easily distinguished from the lung tissue on both sides. Within the shadow, which was otherwise uniform in character, on both sides one saw the shadows of gas bubbles, as well as those of the barium particles from the meal which the patient had had



Fig. 2. After passing through a normal esophagus, the barium fills the stomach by travelling from the cardia toward the sternum underneath the diaphragm. It then turns upward into the chest cavity and goes straight downward and medially toward the pylorus. The latter is in a normal position, and forces the barium to make again a turn upward to enter the duodenum.



Fig. 3. In this lateral view, both infra- and supra-diaphragmatic portions of the stomach can be clearly seen, together with both loops of the colon. The total extension of both hernias is marked by a large shadow which wraps around both colon and stomach.



Fig. 4. The stomach filled, showing infra- and supra-diaphragmatic portions. Both left and right loops of the colon in the chest are also visible.

six hours before. The diaphragm could be clearly distinguished, being lower on the left side than on the right. The posterior part of the diaphragm, being next to lung tissue, was clearest. It moved with respiration. With the patient in the Trendelenburg position, the size of the mass did not change, nor was there any considerable change seen with the Mueller or Valsalva tests.

A barium meal given to the patient (Figs. 1, 2, 3, and 4) revealed a normal esophagus. The cardia contained a gas bubble. The barium appeared to remain there for a short time, but, when the patient was placed in a lateral position, one saw the barium travel forward and medially along the lower surface of the diaphragm until it reached the anterior chest wall. There it made a sharp turn upward, penetrating through an aperture in the left sternocostal attachment of the diaphragm into the chest cavity on the left side. It remained in this location for a considerable length of time. Finally small portions traveled in a straight line down-

ward and medially to a point which corresponded to the position of the pylorus, to the right of the median line. To pass through the pylorus, it made another sharp turn upward, entering the apparently normal duodenal cap, and passing through the duodenum into the jejunum. The bulk of the barium remained in the cardiac and supra-diaphragmatic portions of the stomach, giving the impression of a dumb-bell.

After six hours, the small intestines were in normal position, the stomach was empty, and the head of the barium column had reached the middle of the transverse colon. The ascending colon rose straight upward and medially to an aperture in the right sternocostal attachment of the diaphragm, at which point it was bent like a water hose over a sharp edge. In the right chest, it formed a loop, returned to the aperture in the diaphragm, turned again 360° around the sternal attachment of the diaphragm into the left chest, formed a loop around the stomach, and then re-entered the abdominal cavity, to continue into the pelvis in a normal manner as the descending colon. The barium enema flowed freely and without



Fig. 5. Anteroposterior view after a barium enema, with the barium meal in the stomach. The loops of the ascending and descending colon correspond to the holes in the diaphragm at the level of the eleventh dorsal vertebra. The loop in the transverse colon has pushed the sternal portion of the diaphragm upward to a point opposite the upper margin of the tenth dorsal vertebra.

stopping at any of the three sharp turns through the hernial rings. The impression was that all the organs were fixed in position in the apertures of the diaphragm. Neither the Mueller nor Valsalva tests in the upright, horizontal, or Trendelenburg positions was able to produce a change in position of the stomach or colon (Figs. 5, 6, 7, and 8).

As the colon and stomach did not entirely fill out the supradiaphragmatic shadows, it was concluded that the omentum was also a part of the contents in the hernial sacs. The sternal portion of the diaphragm was apparently a narrow strip of muscle, which, due to the increased abdominal pressure on the transverse colon, had been pulled somewhat upward. There was no evidence that the liver or the small intestines had penetrated into the chest. The heart always lies posterior to the two loops of the colon. It

had not moved to either side, but appeared to be pushed back slightly. After evacuation of the enema, only a small residue of barium was distributed throughout the colon.

COMMENT

The patient did not give any history of an accident, which led to the conclusion that the hernia was a congenital defect. After the removal of the huge fibroid tumor, the previously well balanced arrangement suffered the loss of its support. The ascending and descending colon started to pull downward, and thus produced a sharper turn around the rings in the diaphragm, with symptoms of stricture whenever the patient inclined toward constipation. The symptoms of shortness of breath are easily explained by the fact that the colon interfered with the closely adjacent heart. Healy's syndrome of substernal pain, regurgitation when in the supine position, dyspnea, and vague stomach distress is also present in this case. Contrary to Healy's findings, this patient had considerable pain in the epigastrium. There were no complaints of vomiting or hyperacidity. A gas bubble in the cardiac portion of the stomach was always present, which is contrary to LeWald's experience, who found it absent in cases of diaphragmatic hernia with involvement of the stomach. This is explained by the long course the barium took under the diaphragm, contrary to that in hernia of the esophageal hiatus or other posterior hernias, in which the stomach turns directly upward.

It was most interesting to observe the excursions of the diaphragm and of the upper margins of the hernias. With normal respiration, the hernias showed almost no excursion, and the posterior half of the diaphragm moved slowly and equally up and down. Most of the breathing was done with the muscles of the thorax. With inspiration, the shadow of the hernias seemed to grow larger, as the receding diaphragm allowed

the basic part of the hernias to be exposed. This phenomenon, which became more prominent with deeper inspiration, could best be seen when using the Mueller test on the patient. This test consists of a forced inspiration, which is suddenly stopped by letting the patient close the glottis while he is still trying to inhale. The diaphragm will descend to an extreme position, and the hernia, through the flattening out of the diaphragm, as well as through the increased negative pressure in the chest, will appear larger. Besides, the increased negative pressure may aspirate an additional amount of contents from the abdomen. By this method one successfully can demonstrate hernias which under ordinary circumstances would escape the eye of the examiner, due to being too small or to having been spontaneously reduced in the position observed.

The Trendelenburg position, in which the patient is to be placed in order to increase the pressure of the abdominal organs upon the diaphragm, is indispensable in the examination for diaphragmatic hernia, with and without the Mueller and Valsalva tests. The Valsalva test is not so useful as the Mueller test, but it aids considerably in making a differential diagnosis. After a deep inspiration the patient closes the glottis and tries to make a forced expiration, resulting in an upward motion of the diaphragm. If there is an abdominal type of breathing, as in males, the increased abdominal pressure, which may be higher than that of the thorax, may drive abdominal organs or parts of them through the locus minoris resistentiae of the diaphragm into the sac of the hernia. But, if the pressure of the thorax plus that of the diaphragm is higher than the abdominal pressure, as in the thoracic breathing of females, the hernia may be reduced or may disappear entirely, unless adhesions hold it in position. Both tests may be employed with success for differential diagnosis of hernia and pleuritic adhesions, encapsulated pleuritic exudates, and so on.

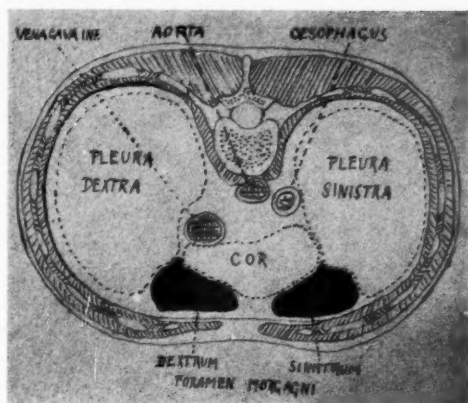


Fig. 6. Cross-section through the diaphragm showing the hernial rings in the left and right foramina Morgagni.

In cases of unilateral hernia, there is a paradoxical upward motion of the diaphragm, as well as of the sac, at the beginning of the inspiration. The motion of the hernia is imaginary only insofar as the diaphragm recedes and allows one to visualize more of the base of the sac. Before entering upon the downward motion, the diseased side will go up and, with it, the hernia. The reason for this is that the function of the perforated side is not so good as that of the normal side. The excursions of the normal side, therefore, are greater. With beginning inspiration, the pressure of the normal side and of the abdomen will be transferred to the weaker side. It will push the latter upward until it has gained strength enough to overcome this pressure and to join with the normal side in its downward motion. Naturally, this phenomenon is more evident in the abdominal type of breathing, and, for this reason, the sex of the patient, in some cases, governs the findings.

In our case, the above mentioned tests could not be demonstrated as clearly as in others, as the hernia was bilateral. The tests brought out very clearly that the sacs of the two hernias were fixed in position, together with their contents. Neither the



Fig. 7. Right oblique view, showing the extent of both hernias. The posterior portion of the diaphragm is intact.

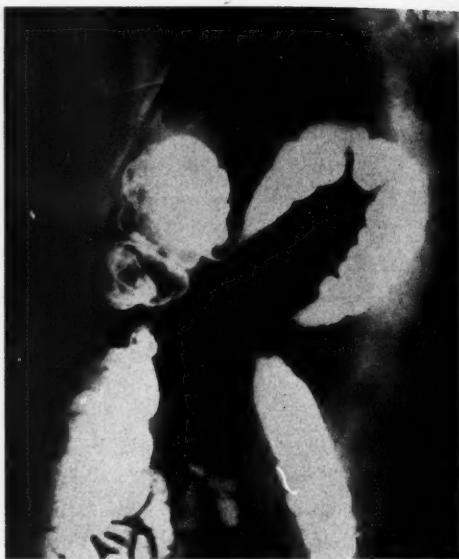


Fig. 8. Left oblique view. The shadow of the left hernia may be seen separated from that on the right. The sacs contain parts of other abdominal organs, as well as the colon.

upright, horizontal, nor Trendelenburg positions changed their size or shape.

TREATMENT

Though the possibility of intestinal obstruction is present, it is rather small, considering the patient has always had this condition. She refuses any kind of surgery, so that a pneumoperitoneum has not been undertaken. Therefore, the treatment should consist of general medication to prevent constipation. The meals should be small and frequent, nor should the patient take strenuous exercises. If she follows these few rules, there is no reason to believe that the condition should shorten her life or cause greater distress.

SUMMARY

1. Diaphragmatic hernia is more frequent than is generally believed.
2. A case of bilateral diaphragmatic hernia through the left and right foramina

Morgagni is reported. This the author believes to be the only case on record.

3. In addition to the Trendelenburg position, the Mueller and Valsalva tests are recommended as valuable aids to the diagnosis of diaphragmatic hernia.

4. A short review of the literature is offered.

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DISCUSSION

DR. G. E. PFAHLER (Philadelphia, Pa.): These cases, which must be very rare, are of more than mere inquisitive interest. Review of them will often help us, if we should have such cases presented to us, to avoid making some serious mistake. A patient suffering from this lesion may have either serious abdominal or thoracic symptoms. It would be very easy with a hasty or careless examination, either physical or roentgenographic, to make a wrong diagnosis and get into grave difficulties. Therefore, when a case such as this is brought to our attention, it makes us all a little bit more alert.

I will illustrate what I have in mind. About ten days or two weeks ago, a patient was sent to Dr. Gabriel Tucker at the Graduate Hospital, in Philadelphia, for the removal of a foreign body in the lung. A roentgen-ray examination had been made, and the patient had been studied elsewhere, but Dr. Tucker is especially particular about having roentgenographic examinations carefully made before he will undertake a bronchoscopy.

When we studied this patient, instead of finding a foreign body in the left lung—which was diagnosed, and which Dr. Tucker was expected to remove—we found a total absence of the left side of the diaphragm, with the large and small intestines filling most of the left lung area. The stomach was down in the abdomen. The patient had thoracic symptoms. This 12-year-old child had gone these 12 years without having any serious symptoms.

It is remarkable how many patients with these congenital defects, exemplified by the case reported by Dr. May, as well as those reported by others, go through a long life, sometimes reaching old age, before anybody even suspects this very serious defect. Most of us think we could not live with this lesion. In general, I think that, when we find these conditions, we must not interfere too much with Nature's method of dealing with our problems. When we do, we will perhaps add to the difficulties rather than lessen them.

DR. MAY (closing): Diaphragmatic hernia is not so rare as we have all thought it was. It creates symptoms which might represent almost anything. To find a small diaphragmatic hernia might solve much trouble for which the patient comes to his physician. It may possibly be operated upon, and the patient cured; but it is difficult sometimes to find the hernia unless we look for it. Just as we look for gastric ulcer, or for any other abdominal or chest condition, we should always, with every gastro-intestinal and chest examination, think of the possibility of diaphragmatic hernia.

THE SIGNIFICANCE OF THE RADIOLOGIC FINDINGS IN LOW BACK PAIN

A REVIEW OF 500 CASES

By WALLACE DUNCAN, M.D., Cleveland Clinic, CLEVELAND, OHIO

AT first glance it might appear to be sheer presumption for one primarily interested in orthopedic surgery to attempt an evaluation of the radiologic findings in a group of patients complaining of low back pain, but it is quite evident that the merit and the significance of this procedure are determined by the clinical application of the facts elicited by roentgenographic examination.

When one considers that the radiologist at one time or another reviews the roentgen plates of virtually every one of these patients during the course of his or her disability, it would seem perfectly logical to present before this organization the findings elicited in the review of a rather large group of cases. The records of 500 consecutive patients presenting themselves in the department of orthopedic surgery with the predominating complaint of distress of one or another type in the lower back have been reviewed. No attempt has been made to approach the situation with preconceived ideas about the findings anticipated, other than those that are bound to be impressed upon one as the result of repeated clinical observations.

Doubtless every radiologist on many occasions is asked by the clinician for his opinion as to whether or not what is seen is sufficient to produce symptoms varying greatly in degree and character in different individuals. Consequently one feels justified in mentioning certain phases of the problem of low back pain which bear out certain fundamental beliefs. Can anyone with any degree of certainty or justification voice any opinion upon the status of any case from the mere radiologic aspect, except in certain patients manifesting definite de-

structive lesions? Is the clinician always within the realm of certainty when he feels that the hypertrophic changes in the lumbar spine or the sacralization of the fifth lumbar transverse process are the agents productive of a patient's backache? No more striking demonstration of the futility of haphazard investigation and opinion can be found than in the woman, aged 35, whose lumbar spine on roentgenologic examination reveals nothing pathologic and yet who is markedly incapacitated for her household duties. Likewise the radiologic findings are of little clinical significance in the case of the man of 65 who presents himself because of urinary difficulties, whereupon examination of the genito-urinary tract reveals hypertrophic changes of marked degree in the lumbar spine, yet the patient has never known the meaning of backache or lumbago.

The statement to follow may be at absolute variance with the opinion of many, but nevertheless it is the outgrowth of the careful clinical investigation of a large number of such persons in every walk of life. Unquestionably first in order of importance stands the accurate recording of facts from the inception of the patient's complaint. Secondly, and of almost equal importance, is the general physical examination to include comprehensive investigation of possible foci of infection and the analysis of body habitus. The relegation of roentgenographic examination to a minor position is in no way intended to minimize the importance of and the necessity for x-ray investigation, but rather to stress those features of the problem which are so frequently thrown into the discard and overshadowed because of a radiographic report revealing a departure from normal which may have no bearing

whatever upon the symptoms. The necessity for radiologic study is manifested by the fact that each of these patients and all others with similar disability are routinely examined in the radiologic department; yet if the history and physical examination were relegated to second place, there would be no criteria for judgment in the large group of patients suffering from low back pain, in whose x-ray plates no evidence of pathologic change is found. It is obvious that the purely clinical aspect of the situation can not be ignored and if the study of these patients is carried out in an intelligent and comprehensive manner, the basis of their symptoms can be determined as accurately, if not with even greater certainty, than in the majority of intra-abdominal and intrathoracic abnormalities. The significance of all findings can be determined, just as in the solution of the problem of the chronic arthritic patient, only by the co-operation and the collaboration of the radiologist, the nose and throat specialist, the dentist, the gynecologist, the genito-urinary surgeon, the neurologist, and the orthopedist.

In this discussion I can not deal in detail with the therapeutic phases of the situation, but here again it has been demonstrated that haphazard methods of approach both on the part of the physician and the patient are productive of disappointment and the discrediting in the minds of both of therapeutic measures basically sound, if properly applied. The results obtained do not depend more upon the accuracy of diagnosis or upon the conscientiousness with which the treatment is pressed than upon the co-operation of the patient in adopting the treatment indicated. End-results depend upon the status of the patient, his economic limitations, his intelligence, and his industry.

As to the types of disability presented in this analysis, I shall refer, first, to that person so frequently encountered and best exemplified by the younger woman, possibly of asthenic type, who may or may not have

had backache since adolescence. She commonly develops an ache in the lower back on getting about after delivery of a child. This patient gets up in the morning feeling absolutely free from her discomfort. She never has any stiffness in the lower back on bending over or on turning in bed. As the day wears on, her backache develops and to secure relief she may be forced to sit down, or even to lie down, with her hand or a pillow placed beneath the small of the back. She has become wedded to a corset because her "back would break" if she did not wear it. During her menstrual period her symptoms are much worse. This is the classical history of the patient, who, on examination, shows a more marked hollowing of the lower back than normal, free movement in all directions, with the production of her typical discomfort on hyperextension of the spine, and tenderness on pressure over the lumbosacral joints and the lower lumbar spinous processes. This patient has bad posture—a mechanically defective back—a genuine disability, in many cases highly incapacitating.

In the group of 500 cases, about 170 cases, or 34 per cent, fall primarily into this category. Of these, 78 per cent were females, and an anomaly of the lumbosacral region was recognized once in every 15 cases. In two-thirds of these patients the roentgenograms were reported as negative, while the other third showed some variance from normal, either a sacralization of the fifth or sixth lumbar transverse process, mild arthritic changes, or a slight scoliosis to one or the other side. These plates were all taken in the recumbent position. With this evidence, there is no contra-indication to the institution of physical therapeutic measures. In this group, the confirmatory rôle of the roentgenogram in ruling out destructive lesions, in determining whether or not contra-indications to certain forms of therapy exist, is doubtless the greatest indication for further radiologic investigation.

The question might be raised as to whether any benefit accrues from the substantiation contributed by the roentgenographic findings. In no case in this group did the x-ray findings materially influence the therapy instituted, but they substantiated the *rationale* of the treatment. Lateral plates, particularly of the lumbosacral region, taken in the erect position, contributed even more to the accurate analysis of the clinical picture. It is in this type of patient that nothing supplants the regimen of adequate rest, the avoidance of fatigue, the elimination of focal infection, the adoption of a sane dietetic routine, the application of heat locally, massage, instruction in muscle re-education, with the correction of mechanical defects, and, in a fairly high proportion of cases, the adoption of a brace or corset. Pelvic inflammatory disease has been found to be a rare cause of this type of disability: Focal infection was present in 73 per cent of these patients and prostatic infection was looked upon as a factor in 11 of the male patients; syphilis was present in 5 cases.

Every one is familiar with the group of patients typified by the short, thick-set man who has done heavy work and who from his early thirties may have been subject to recurrent attacks of lumbago, with periods of perfect freedom between attacks. As time goes on, he commences to have stiffness on bending over in the morning, with the disappearance of discomfort on so-called "limbering up." Toward the end of the day, on arising from a chair, discomfort and stiffness are again in evidence. Some mechanical defect may be shown on physical examination, but, more often, there is definite limitation of movement, with virtually no localized tenderness on pressure over the lower back. Heberden's nodes may be present, and crepitation in the knees frequently may be felt. A smaller group of elderly persons, particularly women, may present all the characteristics of an atrophic process, and in others may be found the

rigid spine of the ankylosing type of arthritis. It is in this group that infection and metabolic disturbances probably play their greatest rôle, and doubtless many of the patients in the group under investigation in whom no lesion is shown radiologically may not have reached the stage of gross change manifested in the lumbar spine. Into this category have fallen 230 patients, of whom 160, or approximately 70 per cent, were males. Among these, focal infection was demonstrated in all but 30 cases and 56 were suffering from chronic prostatitis. There were 3 patients with syphilis.

In this group, 61 patients (virtually all males) presented definite evidence clinically of acute infectious arthritis of the sacroiliac joint. There is little or no radiologic evidence to support this diagnosis, and in this group of cases little assistance, as a rule, is obtained from roentgenographic study. In those with an infectious basis, one concludes that tonsillar, prostatic, and dental infection play highly important parts, since one or more foci were readily demonstrated, almost without exception. This infectious condition is always made worse by manipulation.

In 158 of these 230 cases there were changes demonstrated radiologically which would have been anticipated from the clinical examination. It is obvious that many of these patients had an early arthritic process without any radiologic evidence of it. In this group, there is a distinct discrepancy between the clinical impression and the radiologic findings in many instances. In the 72 cases in which the roentgenographic findings were reported as normal, it is apparent that, without adequate data obtained from the history and physical examination, the difficulty of the therapeutic problem becomes much greater. In this group, the presence of radiologic changes greatly facilitates the solution of the problem, but the absence of gross change does not demonstrate that the

disease is not present in any one of these patients with arthritic symptoms.

One of the most difficult phases of this problem is the differentiation between lumbosacral and sacro-iliac lesions. A tumor of the lower cord may be confused with this type of disability. The patient with a history of "something snapping" in the lower back during heavy lifting, or the patient with the gradual onset of pain in either sacro-iliac region, with pain referred down the posterior surface of the thigh and the outer side of the calf to the ankle, presents the classical complaint of a sacro-iliac lesion. These symptoms are always aggravated by activity and relieved by rest. Marked pain on straight leg raising, with discomfort referred to the affected sacro-iliac joint, and pain slighter in degree in the same joint on straight leg raising on the opposite side, are common accompaniments of this symptom-complex. Frequently the differential diagnosis has to be made between a sacro-iliac lesion and a tumor of the spinal cord because of typical pain on coughing, sneezing, and straining at stool. These particular symptoms are by no means pathognomonic of cord lesion, as some orthopedists believe.

In cases due to injury, manipulation, applied promptly and adequately, results in improvement. Fractures of the lumbar spine accounted for 18 cases of disability in the lower back. About forty patients in this series fell into the group with trauma to the sacro-iliac region. In this group fractures were readily demonstrated in a lateral film and on clinical examination presented little difficulty in diagnosis, since a history of trauma in such instances was recorded.

Thirty-seven cases were encountered in this series in which destruction of a malignant or tuberculous character was manifested. There seems to be a definite disparity in this column, as compared with the statistics of other workers, and a proportion as low as this might not be encountered in another series of cases studied over a period

of many years. Of these 37 patients, 17 had Pott's disease. In most of the cases of malignancy, the changes in the spine were obviously metastatic. In these cases, severe back pain, especially at night, in the presence of primary malignancy is highly suggestive of spinal metastases despite negative roentgenograms. Among those exhibiting changes resulting from malignancy, it was proven that two were suffering from multiple myelomas. In the earlier months of observation it was felt that their low back symptoms were the result of some hypertrophic process. In one patient the peculiar phenomenon of coagulation of the blood serum on heating to 55° C. was later shown to be due to the presence of Bence-Jones protein.

No case of Charcot spine was encountered in this group of 500 cases.

In this series of cases, only 5 patients were thought, from a clinical point of view, to have no mechanical, arthritic, infectious or malignant basis for their complaint. There was one case of spinal cord tumor, one of carcinoma of the sigmoid, one in which symptoms apparently arose from a thrombosed internal hemorrhoid, and in two cases the symptoms obviously arose from prostatic disease. No abnormality was shown radiologically in any one of these cases.

It would be purposeless to present illustrations of the conditions discussed, since there is relative unanimity and uniformity of opinion regarding the variations from normal that have been reported.

The most disappointing phase of such a review is the failure to have the opportunity of following these patients over a long period of years. In each case, however, there was sufficient observation to make fairly certain the category in which each case belongs.

In reviewing this group of cases, I feel more than ever that an attempt to prove from roentgenograms alone whether disabil-

ity does or does not exist is an extremely pernicious practice. It is obviously unfair, if it is based upon impressions which have no clinical substantiation, and frequently prejudices the status of a patient who has a perfectly justifiable claim to disability. As an example may be cited the patient with a minimal amount of hypertrophic change who sustains injury to this area, with a subsequent prolonged period of incapacitation. Although a certain proportion may adopt malingering as a means to an end, there still remains a large number of patients with genuine disability, the degree of which can be determined only by adequate clinical observation and analysis. It is equally reprehensible to read into radiographic reports the findings of the problem at hand, when it is certain that if proper discrimination were used it would be proved that the alleged con-

dition could not be present. Injury, either single, severe, repeated, or apparently negligible, and also focal infection might produce in any one of the 500 patients a train of symptoms on the one hand relatively insignificant or highly incapacitating on the other. Intelligent roentgenographic examination and interpretation is essential, and comprehensive clinical investigation is imperative if an accurate analysis is to be made and if rational therapy is to be instituted.

In conclusion, there exists a sufficiently large element of error in the diagnosis of low back pain, regardless of the thoroughness and comprehensiveness of the clinical investigation, to make roentgenographic examination of the area obligatory in order that there may be some degree of certainty as to the fundamental factors involved in the production of the disability.

THE QUALITY DETERMINATION OF THE ROENTGEN RAYS¹

THE HALF VALUE LAYER AS A PRACTICAL METHOD OF ESTIMATING THE QUALITY OF ROENTGEN RAYS

By WILLIAM H. MEYER, M.D., Director of the X-ray Department, New York Post-graduate Hospital, and Professor of Roentgenology, New York Post-graduate Medical School, Columbia University, New York City

THE need of establishing some universally satisfactory and comprehensible method of quality designation of roentgen rays still exists. Though extreme accuracy may not be attainable, nevertheless some method should be adopted which is easily comprehensible and sufficiently simple of execution to be practically applicable by the average medical roentgenologist. The method should not only avoid complexities of procedure, but should be sufficiently simple of quotation as to be readily communicable. My effort, therefore, will in the main be an attempt to determine, by ex-

clusion, the most satisfactory of the present-day methods.

In selecting a standard for quality measurement, it should be remembered that the problem is not limited to high voltage therapy only, but that a vast number of machines are being operated at medium low voltages, with little or no filtration, especially in superficial therapy, and that qualitative standardization is also required in radiography. Any qualitative method of determination that does not encompass the whole field is not worthy of consideration.

Before proceeding with the problem at hand, a question arises which entails a definite moral obligation, namely, Is it right

¹Read before the Radiological Society of North America, at the Eighteenth Annual Meeting, at Atlantic City, Nov. 28-Dec. 1, 1932.

to request and accept for therapeutic purposes qualitative and quantitative calibrations from manufacturers' representatives and lay technicians? In radiography, perhaps the worst that can happen is a poor quality film. For therapeutic purposes, physical measurements by lay individuals may be justifiable; however, whence the authority to designate any given biologic reaction, skin or depth dose? Any statement at the bottom of a calibration chart absolving responsibility for quotations is a subterfuge, an admission of lack of authority. The responsibility for qualitative and quantitative dosage, as applied to the human being, still remains definitely medical.

Whether for diagnostic or therapeutic purposes, all of us must have experienced the uncertainties and vagaries of voltmeters, point, and sphere gap methods of quality estimation on different installations. Though each of us can, with reasonable safety, employ the arbitrary subdivisions of a given voltmeter for technical reduplication on the same installation, how many of us have attempted to transfer a given technic from one installation to another, using given meter readings, and have found that, both in roentgenography and therapy, a totally different type of radiation was forthcoming? If additional illustrative examples are required, we mention several machines recently tested,² all operating under the same sphere gap measurement control. On these, the kilovolt readings varied from 64 to 90—not one of the meters corresponded to the 76 K.V. indicated on the sphere gap scale.

As a further indication of the vacillation in x-ray quality on different installations with voltmeter control, the half value readings furnished some interesting facts. Of the several machines tested, each operated with the same voltage meter reading, only two, machines of the same model, showed any approach to uniformity in quality. In

the others, over 100 per cent variation in x-ray quality was discernible. Transferred to a comparative peak voltage scale, the variations in the half value measurements of the different machines represent a range of from 65 to 110 peak kilovolts. This vacillation would result in severe under- or over-exposure of diagnostic films, or be of serious consequence in therapy.

VOLTAGE QUOTATIONS

Chart 1 shows the approximate voltages in relation to the measured x-ray quality. On the first line, wave lengths in Ångströms are indicated. It is important to remember that these quotations indicate the minimum wave length. Though spectrographic measurements afford a quite accurate means of determining voltage, nevertheless this method of quality measurement fails to indicate the ray quality when strongly filtered radiation is employed. That is, notwithstanding the definite change in the ray bundle produced by filtration, nevertheless the minimum wave length measurements remain practically the same.

The comparative voltage quotations on Chart 1 are quite futile unless strict attention is given to the footnotes. Each of the calibrations will suffer considerable variation, depending not alone upon the type of measuring instrument employed, but varying further with differences in types of currents, methods of rectification, size of condensers, resistances, altitude, etc.

Even discounting the personal element of vacillation, such wide variations in spark gap and kilovolt quotations can be met as are illustrated in Table I, yet with the half value quality measure the same throughout.

VOLTAGE AS A MEASURE OF QUALITY

In Table I, the variations in centimeter sparking distance, with spheres of different size, should be noted (Experiments 2, 3, and 4), also the differences in voltages with

²In conserving expense, three illustrations which can be found in publications referred to are not included here.

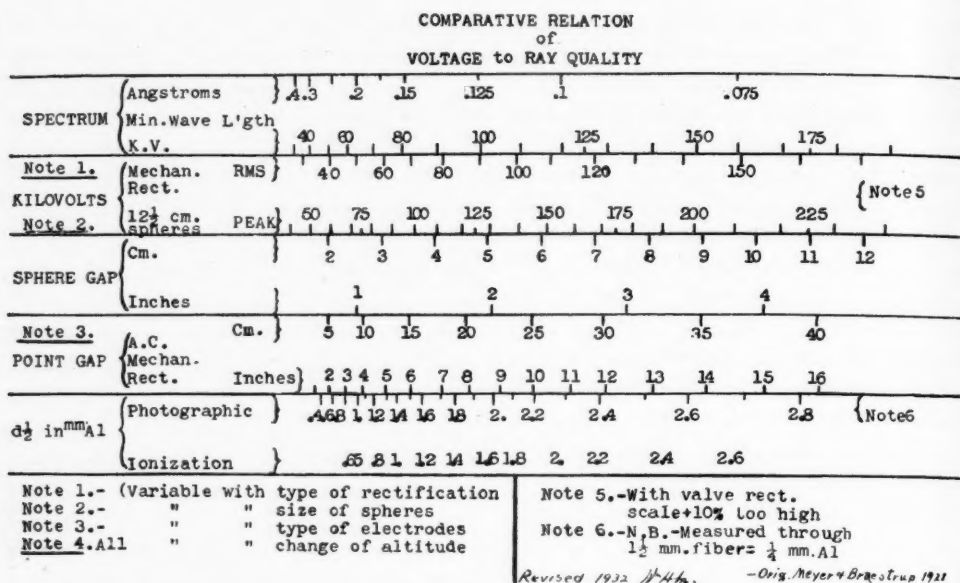


Chart 1. The footnotes on this chart are of major importance in illustrating the uncertainty of most of the present-day voltage quotations.

TABLE I.—VARIATIONS IN SPARKING DISTANCE AND K.V.P. READINGS WITH DIFFERENT MACHINES UNDER DIFFERENT MEASURING CONDITIONS. THE QUALITY OF THE RAY BUNDLE REMAINS PRACTICALLY THE SAME.*

Experiment	Type of instrument	Type of current	Spark distance	Relative kilovolts
1.	Spectrum	Constant potential		150
2.	25 cm. spheres	A.C. 4 valve rectifier	+ 6.7 cm.	(peak) — 180 (R.M.S. 130)
3.	10 cm. spheres	A.C. 4 valve rectifier	— 9 cm.	(peak) 180
4.	12.5 cm. spheres	A.C. 4 valve rectifier	— 7.8 cm.	(peak) 180
5.	12.5 cm. spheres	A.C. mechanical rectifier	+ 9.6 cm.	(peak) 200
6.	Blunt points	A.C. mechanical rectifier	+ 36—cm.	(peak) 200

*In all the above, the half value layer was at +11 mm. Al, using 0.5 mm. Cu as filter.

spheres of the same size but with change in the type of current (Experiments 4 and 5). With other types of electrodes, wide variations between the minimum and maximum sparking distances, as indicated in Experiments 5 and 6, will be observed.

In a former article (2) variations (approximating 160 per cent) in intensity output of different installations were reported. These all operated under presumably the

same voltages. In another communication (3) variation of over 350 per cent between different types of installation was recorded. If to this is added the difficulty encountered in accurately measuring the high capacity, valve tube rectified equipment, especially of the recent condenser type (whether in roentgenography or therapy), the futility of the spark gap method of calibration for quality determination becomes apparent.

COMPARISON OF METHODS
FOR QUALITY DETERMINATION
OF HETEROGENEOUS RADIATION

Half Value Layer	mm. Al	1	2	3	4	5	6	7	8	9	10	11	12	13	14 (A)
Layer	mm. Cu			.1	→ .2	.3	.4	.5	.6	.8	1.0	1.2	(B)		
Percent Transmitted	2mm. Cu through	15	→ 20	30	40	50	60	70	80	90	100	110	120	130	(C)
Transmit	4mm. Al	→ 20	30	40	50	60	70	80	90	100	110	120	130	140	* (D)
Absorb. thru mm. Al Equal to	2mm. Cu	12			11	10	9	8	7	6	5	4	3	2	(E)
Effect Wave Length	1mm. Cu	17			→ 16	15	14	13	12	11	10	9	8	7	(F)
Angstrom Unit		41	36	32	28	24	21	18	16	14	12	10	9	8	(G)
				→	3	27	24	21	19	17	15	13	11	10	(H)

Line G * Transcribed from Method (D)

" G " " " " (F) or (absorption through copper)

" H " " " " (C) or (absorption through copper)

→ Arrows indicate limitation and direction of practical application of method

* Measurements by Desbaur Electroscopie
AC Mechn Rect and Coolidge tube usedrevised 1932 *W.H.M.*
Original Meyer and Brdstrup's

Chart 2. From the several methods of quality determination here charted, the greater numerical subdivisions and wider useful extent of the scale of the half value layer in aluminum should be apparent.

Added to this is the absolute uselessness of estimating ray quality by voltage or any other method than by measuring the ray bundle, when filtration of any kind is employed.

A little experimentation and thought on the matter will force one to the conclusion that the greatest vacillation in intensity output is ascribable to voltage variations. This becomes more apparent when one considers the fact that "intensity varies roughly as the square of the R.M.S. voltage." Experience has taught us that, once a given set of operating conditions has been thoroughly tested, then it is fairly safe to presume, under these fixed operating conditions, that sufficiently constant qualitative and quantitative output will, for a reasonable period, be maintained. Of course, the proviso maintains that no changes of any kind have been made in the installation. This refers to the milliamperage, voltage, time, and distance control, as may be expressed in the

formula $\frac{AXV^2XT}{D^2} = I$ (4). Nevertheless, as the tube ages, or with the slightest provo-

cation or change in operation, an immediate re-check is essential.³

From what has been said, it must be more than apparent that, whereas meter control on a fixed installation, properly standardized, is justifiable, for purposes of communication or reduplication (at the present time), the transfer of voltage quotations from one equipment to another is absolutely worthless as a check on quality.

It is most desirable that a uniform standard of voltage recording be established. However, the problem of quality determination (with filtered radiation) still remains and will be solved only by direct measurements of the emitted radiation.

THE MORE IMPORTANT METHODS OF
QUALITY MEASUREMENT⁴

The adoption of a single method for determining and expressing the quality of the roentgen rays appears to us to be just as

³A routine check at least once a week would not be considered by us to be superfluous.

⁴Because the line of reasoning holds its continuity, the author re-quotes in part, with minor revision, from a former publication (5).

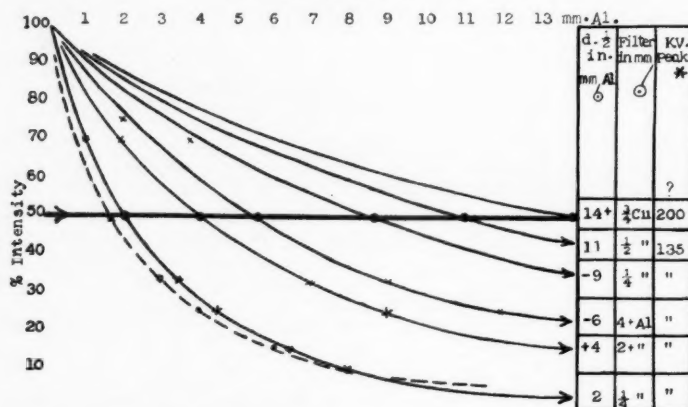
important as the acceptance of a standard unit of intensity measurement.

Our former work consisted of the comparison of several proposed methods for

measurements below 0.1 mm., as is required in Method B (Chart 1).

Thus, for fractional determination of even the half value layer in copper, and for

THE HALF VALUE LAYER
As a Simple & Direct Method of
DEFINING ABSORPTION CURVES



* The peak voltage here designated may vary with different installations.

1916

Chart 3. Though this chart is purely illustrative, the curve projections will be found reasonably correct, since they are a composite of both photographic and ionometric measurements. The relation of the two procedures is indicated in the first two curves; the broken line (measurement by ionization) as compared with the continuous line (photographic measurement) of the same ray quality. That these two lines probably cross one another at shorter wave lengths is indicated at the right-hand end of the curves.

The tangents drawn indicate the main components of the otherwise complex heterogeneous beam. Curves similar to these can be drawn in which copper is substituted for the aluminum as an absorbing medium. There is no doubt but that variations in absorption curves, as here designated, may occur with different voltages and filtration, wherein the same half value layer might be obtained. Notwithstanding these slight variations, by no stretch of the imagination could any difference in biologic reaction be discernible if the intensity in the depth, as indicated by the half value layer, remains the same.

Surely it is evident that the quotation of the half value layer is the simplest form of designating the quality of the radiation employed.

measuring quality. In Chart 2, the experimental results have been re-tabulated. The arrangement is such that the relative advantages of each method may easily be determined. An important point not evident on the chart is the practical difficulty encountered with some of the methods. This is especially true if an absorbing medium of high atomic number is employed in measuring the rays of long wave length. We have reference to the handling of fine thicknesses of metal demanding micrometric

all measurements of unfiltered radiation below 200 K.V., copper in hundredths of a millimeter thickness is required. There are further difficulties in attempting the measurement of small intensities of radiation, as encountered in Methods C, E, and F (Chart 2).

The percentage of variation of the transmitted intensity, with the shorter wave length, is especially small as applied in Method F.

From a detailed study of these data, it

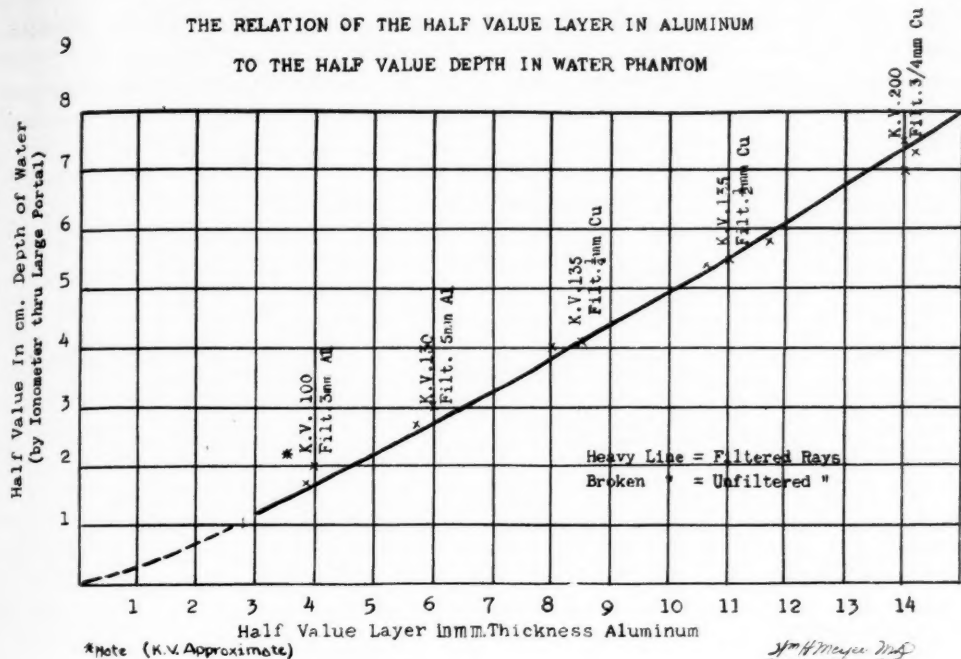


Chart 4. In deep therapy dose estimation, the close relation of the half value centimeter depth and the $d_{1/2}$ in mm. Al is of definite value, since, at each half value layer, the absorption in each 2 mm. Al is almost equivalent to that of each 1 cm. of water (when large portals of entry are employed).

Water phantom measurements by ionization with back-scattering.

The half value layer, in aluminum, measured in air.

will become apparent that the heavier absorbing media, suitable for testing strongly filtered rays, offer serious difficulties in measuring rays of long wave length. Conversely, fixed lighter absorbing media give too narrow a range with rays of short wave length.

It may be worthy of mention further that, in existing tables, the Ångström units as indicated have reference to homogeneous radiation, whereas the practical roentgen therapist is dealing mostly with a heterogeneous beam. Therefore, rather wide variations occur, depending upon the method employed in calculating the wave length, indicated in the relation of Scales D, E, and F, as compared with the effective wave lengths given in Line G (Chart 2).

The lack of continuity and the disparity

in wave lengths, noted in Line G, are due to the change in method of determination as indicated. It will be observed that the rays of longer wave length have been derived from Method D, in which the percentage transmitted through 4 mm. Al has been measured. Even here, this thickness of aluminum will be found to be too great for practical purposes in attempting the measurement of transmitted radiation intensity below 150 K.V. unfiltered. For a similar reason, the effective wave lengths of shorter rays, as derived from Methods E or F, are entirely impractical of application when the Ångström wave lengths are above 0.17.

It might be well to mention here that, for the practical roentgenologist, there is as yet no simple and direct method of determining the effective or average wave lengths. The

latter are usually derived from chart or scale deduction through some more or less complicated intensity or absorption measurements (6).

plex, heterogeneous radiation employed in the average diagnostic and therapeutic x-ray department is vastly different from the supposedly homogeneous Ångström wave

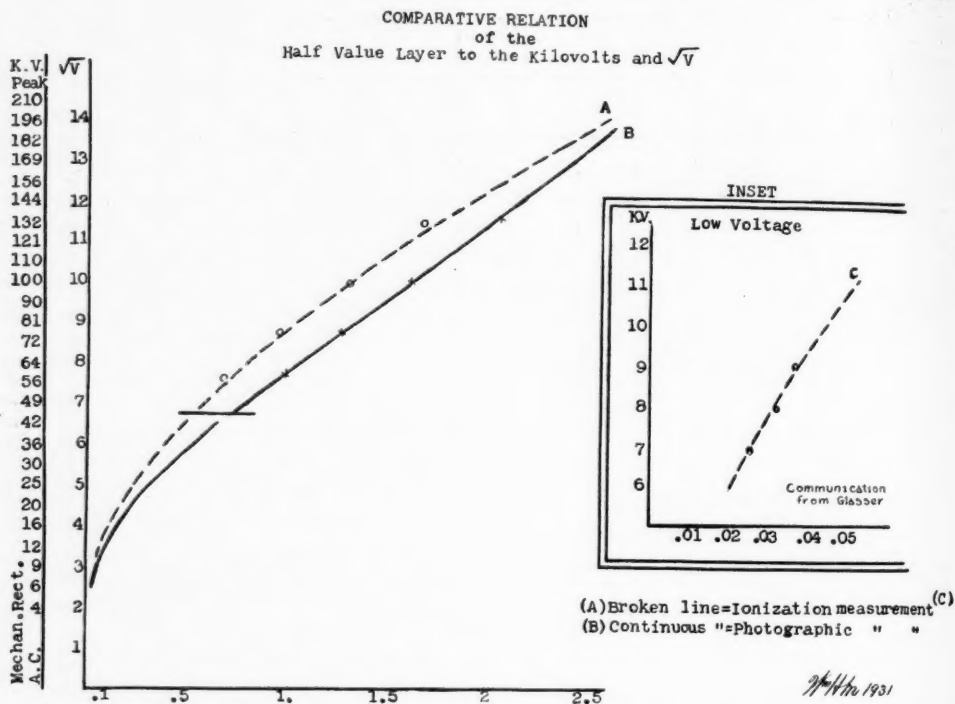


Chart 5. This chart is for the purpose of showing the approximate relation of kilovoltage to the half value measurements both by ionization and the photographic method.

The data were obtained by using mechanically rectified A.C. current and a Coolidge universal tube. In charting curves A and B, the equivalent of 0.25 mm. Al as a filter was used, the measurements under these conditions extending from 50 K.V.P. upward. Below this voltage, the curves are only relative.

(For lower voltages, we refer to the insert in which the half value measurements in relation to low voltages have been transcribed from a communication by Glasser.)

The data on the main chart have repeatedly been reduplicated on the same installation with less variation than 0.20 mm. Al in the half value measurements.

In re-duplicating these data on other installations, especially of the valve tube rectified type, a definite shift in the relation of the curves to the K.V.P. measurements will be observed, the half value measurements usually being considerably higher in relation to any of the given voltages. In other words, according to our observations, the whole peak voltage quotations could be lowered approximately 10 per cent from the figures given on the chart, the curves thereby holding the same relative position as here indicated.

Naturally, far wider variations have been, and will be, obtained with different tubes on different installations. This, however, is a further reason for recommending a substitution of half value measurements for any other method of quality designation.

The establishment of the minimum wave length is no criterion of either the average or effective wave length. Thus, again, variations and confusion arise according to the quotation and method pursued. One should further heed the fact that the com-

length quotations appearing in the physicist's laboratory data.

By force of necessity, brought about by the requirements of concise teaching, the author devised and described (7) an instrument for the purpose of photographically

determining the transmitted intensity or absorption through fixed substances. This instrument is thoroughly applicable for such deductions as are indicated in Methods C and D on Chart 2, including any variations thereof, and covering also Methods E and F.

It is, of course, possible to state directly the percentage of radiation transmitted through fixed media. This method, a short-cut procedure sometimes employed in the calibration of different installations, may, for relative comparative purposes, be justifiable. The method, however, has the same limitations indicated in Methods C, D, and E in Chart 2, with the added necessity of employing variable thicknesses of absorbing media for widely different ray qualities.

Though a most comprehensive method of qualitative study is afforded by the creation of transmission or absorption curves, the method is rather complicated. It requires numerous measurements, under rather difficult conditions, and, except by translation through charts, does not lend itself to readily communicable, simple statement.

THE HALF VALUE LAYER AS PREFERENTIAL QUALITY MEASURE

Yielding to the desire for greater simplicity and clarity of presentation, which would combine inexpensiveness with reasonable accuracy of execution, the photographic method of estimating the half value layer in aluminum, as here devised, was re-adopted. As the years pass by and my experience with class instruction continues, the conviction of the value of the method has become so strong that some simpler and more accurate method will have to be presented ere we discard the half value method.

As a foundation for our argument, may we re-quote our belief in a statement accredited to Christen (1) many years ago, and not yet refuted: "Eventually all quality determinations of the roentgen rays will have

to be calibrated against the half value method."

It is unquestionably true that, in expert hands, the ionometric method of determining transmitted intensities or the half value layer affords greater accuracy than any other procedure. However, repeated comparative tests with the photographic method have revealed such uniformity as to suggest that this procedure is sufficiently accurate for orientation purposes.

The photographic method of determining the half value layer has the further advantages that, when the control of the exposure is reasonably correct (within the wide limits of photographic readability), then interpretation and quotation are made directly from a single film. Each film is a permanent record permitting protracted study and preservation for review and future comparison. On different tests, variation in intensity is of no serious consequence. Though uniformity of photographic intensities is desirable and attainable, by variations of the time or distance factors in the formula $\frac{AXV^2XT}{D^2} = 1$, it is not absolutely essential.

One of the most important points deserving of reiteration is that the readings are made directly and quoted as such, *i.e.* ($d \frac{1}{2}$ in mm. Al), meaning the half value layer in millimeters of aluminum. Neither comparative charts nor transcription is required.

The half value method, by ionization or photographically, especially with aluminum, can be used over a considerable range of wave lengths with the least number of the objections mentioned. Though the determination of the half value layer in copper with the rays of shorter wave length has certain scientific advantages, there is either the difficulty of handling extremely thin layers (as previously mentioned) or the necessity of substituting another medium for measuring the soft rays, thus introducing double, or even multiple, standards.

The advantages of using the half value layer in aluminum as a quality measure appear to be:

1. But a single type of absorbing medium is applied throughout the full range of wave lengths.

2. Simplicity of statement, with a single unit standard, avoiding transcription.

3. The method is reasonably simple of application and, for practical purposes, affords sufficient accuracy over a wide range of wave lengths (3, 5).

Should greater accuracy be desired, the preliminary establishment by the photographic method of the half value layer as a guide will determine, within a fraction of a millimeter, the thickness of the substance. Final check may be done by the iontoquantimeter. The number of experimental test readings to be made with the iontoquantimeter is thus reduced materially. With a little practice and experience, the photographic determination of the half value layer will be found to parallel closely the results obtained by the iontoquantimetric method. For practical purposes, the photographic method would appear to suffice for orientation in the average radiologic laboratory.

Chart 3 is inserted to illustrate the simplicity with which the designation of the half value layer permits of simple definition of an otherwise complex procedure. When such transmission curves are established by ionometric measurements, then it is necessary to determine at least three points with any given quality of radiation: (1) Without the absorbing medium; (2 and 3) two or more readings with progressively increasing thicknesses of absorbing medium.

By the photographic method a direct reading of the half value layer is attainable.

THE RELATION OF THE HALF VALUE LAYER TO DEEP THERAPY

By comparing the 50 per cent intensity level on various isodose charts (derived

from water phantom measurement)⁵ with the half value layer in millimeters of aluminum (Chart 4), a remarkably useful curve will be observed. It will be found that, with filtered rays (beyond the second centimeter depth), each 50 per cent intensity level as measured in water, with different voltages and filtration, is roughly equal to one-fifth the thickness of the half value layer as measured in aluminum. In other words, the absorption through each 1 cm. depth of water is closely equivalent to that through 2 mm. of aluminum (under the conditions mentioned). Therefore, a definite relation between the measured quality of radiation and the depth dose can be established. Around this fact our method of dose calibration has been built. Above all, we have the ability to refer to and completely re-establish and duplicate any dosage that was employed during the more than 20 years of use of this quality method of measurement.

CONCLUSION

The half value layer, because of its simplicity, is a most valuable method of quality definition and is deserving of universal adoption.

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DISCUSSION

MR. R. B. WILSEY (Rochester, N. Y.): Dr. Meyer referred briefly to some photographic determinations of half value layer, and, in the discussion, the photographic method has been given considerable additional attention. It seems desirable, therefore, to utter a word of warning regarding the use of photographic materials for measurements of radiation intensities.

This morning, Dr. Failla pointed out the distinction between precision and accuracy in ionization measurements, showing that extraneous effects arising from the design of the ionization chamber could influence greatly the reliability of the results, even though the instrument were carefully used and the readings precisely made. A similar distinction applies to the use of photographic materials for intensity measurements. It is much more difficult to avoid the difficulties inherent in photographic measurements than it is in ionization measurements. Sometimes the photographic method offers the only practicable possibility of making the measurements desired; in such cases, useful results can generally be obtained if the necessary precautions are followed and the interpretation of the results is properly restricted. Therefore, while photographic methods of measurement may be used under special circumstances, they are not to be recommended for general application in the measurement of radiation intensities.

Most of the half value layer data reported by Dr. Meyer, and those on which he placed greatest emphasis, were obtained with the ionization chamber, and quite properly so, since the ionization method is much to be preferred to the photographic method for this purpose.

DR. I. S. TROSTLER (Chicago, Ill.): My impression is that Dr. Meyer is not advocating the photometric method of dose determination, *per se*, with any idea that it will or should supplant the ionization method, but that he is presenting it as an easy and readily applied means of determining the half value

layer dose, particularly for use in more or less superficial therapy.

As such, it appears to me to be not only easy of application without expensive and delicate instruments but also another and additional method of recording data capable of aiding in the defense of malpractice suits.

During the last three or four years, not a month has passed in which I have not been asked for advice in the defense of damage suits. I am sorry to say that, in the great majority of them, the only method of dosage computation or determination is the milliamperage, voltage, distance, time, and filter, and almost invariably, the voltage used must be guessed from the spark gap, from points of various acuity. If all of these defendants had applied some such simple means of measurement of the dosage as the photometric method outlined by Dr. Meyer, most of these damage suits would assume a very, very much less formidable aspect. I mean that the defendant physicians would be able to testify that some accurate means of dosage measurement had been applied during or before the application of the treatment complained of, and expert testimony might be introduced to verify properly the correctness of the dosage used. So that, aside from the actual scientific and therapeutic value of the photometric method in the determination of the dosage to be administered, as presented by the essayist, its use has great possibilities of being valuable as another means of recording dosage, to help us in defending damage suits charging malpractice.

Because of the multiplicity of malpractice suits being filed, may I again urge all who use roentgentherapy to keep careful records of the technic and dosage applied in every instance, and the figures and methods of dose determination. We do not know who will be next to be served with notice that suit has been started, so we must constantly bear in mind that "Eternal vigilance is the price of liberty," even when discussing roentgentherapy.

DR. MEYER (closing): From the discussion, it is evident that some of the gentlemen

have missed the point of the presentation. It was not intended to evaluate the photographic *versus* the ionization method for intensity measurements. As a matter of fact, all of the data in the charts presented (except when specifically mentioned) were obtained by ionometric measurements.

If the ideal and perfect method of quality determination existed, this presentation would not have been required. As matters stand, the definition of quality by means of the half value layer (expressed as $d_{1/2}$ in mm. Al) appears the most logical. Whether this information be derived from absorption curves or direct half value measurements is immaterial, so long as uniformity of procedure and expression is established. As an absorbing medium, aluminum has a greater

range, especially in the longer wave lengths, and can be used practically throughout the length of the scale, though copper may afford greater accuracy with the shorter wave lengths.

The creation of a uniform standard of voltage measurement is most desirable, but the need for direct radiation quality determination still remains. Insofar as the photographic method of establishing the half value layer is concerned, with reasonable experience, a remarkably useful parallelism will be found between these measurements and those obtained by ionization.

Until some such method of quality definition as here presented is accepted, the present-day chaos will continue.

THE X-RAY AS AN AID IN THE TREATMENT OF GAS GANGRENE¹

Bacillus welchii INFECTION—PRELIMINARY REPORT

By JAMES F. KELLY, M.D., Associate Professor of Radiology,
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LATELY it has come to the attention of the writer that a six-year-old boy had an arm disarticulated at the shoulder for a gas bacillus infection in the forearm, and that two deaths have occurred within the last three months in nearby hospitals from the effects of this infection, in spite of the usual frantic surgical and serologic efforts to effect a cure. The end-result in these cases was undoubtedly unavoidable yet within three years the writer has observed six cases involving the extremities which have all seemed to be benefited by the use of small doses of the x-rays. Five of the six cases were seen in St. Catherine's Hospital, where the first case was treated with x-rays on Aug. 1, 1928, and where this method of treatment is now used, in

addition to other measures, on all gas gangrene cases. The writer is, therefore, taking the liberty of reporting these few cases with the idea that, if there is any value in this form of treatment, it may be used when necessary, as everyone has access to x-ray apparatus and no special knowledge is required for applying the mild dosage used by the writer.

One naturally hesitates about reporting any results on such a small series. However, the condition is not met with frequently enough in time of peace to warrant a longer wait in order to accumulate a larger number of cases. If the method has any merit, it is offered here so that many others may have an opportunity to use it, and so that its value, if it has any, will be more quickly established. Furthermore, roentgentherapy is not offered as a specific. In every case it

¹Read before the Radiological Society of North America, at the Seventeenth Annual Meeting, at St. Louis, Nov. 30-Dec. 4, 1931.

was employed only in conjunction with the other usual therapeutic measures; this fact renders any claim, at this time, for its specific action out of the question. However, it is acknowledged by all unbiased observers (1, 2, 3) that roentgen treatment of many localized infectious processes, due to other types of organisms, has been so definitely beneficial in the past that to neglect its use in gas bacilli infection may truly be considered poor judgment. In fact, x-ray treatment of these localized infections has been so successful and the results so widely published for the past twenty-five years or more that it seems unnecessary to make a plea for its use in such a fulminating and serious infection as gas gangrene usually proves to be. However, the use of the x-ray as an aid in the treatment of localized infections seems to have escaped the attention of many sincere practitioners. Since gas gangrene has not been mentioned specifically in this connection, is it not but fair that this form of treatment be called to the attention of those not engaged regularly in the practice of radiology?

No animal experimentation has been completed as yet, and, judging from recent events, valuable time may be lost by waiting on such procedures. The experimental laboratory work now in progress on the treatment for gas gangrene and tetanus infection by the Radiological and Pathological Departments of the School of Medicine, Creighton University, will be reported at a later date. In the meantime, in the treatment of a serious infection, any simple measure which does not interfere with other indicated measures, is not inherently dangerous, and appears to be beneficial on all occasions, should be employed regularly regardless of possible lack of confirmation from the laboratory.

In this preliminary report roentgentherapy is recommended merely as an aid in the treatment of gas gangrene infection, with

the hope that it will be used as such wherever it is indicated. It does no harm, is easily applied, is accessible to all, and apparently does some good. In at least three instances in this small series, amputation was deferred to see what action x-rays would have. Amputations were unnecessary in these three cases, as improvement followed immediately after the first x-ray treatment, and all the patients recovered.

CASE REPORTS

Case 1. F. P., farmer, age 21 years, entered the hospital on Aug. 30, 1928, with a laceration below the right knee, following an auto accident. Clinically the infection which followed looked like gas gangrene. The laboratory cultures were positive for *Bacillus welchii*, and x-rays films showed considerable gas in the soft tissues. Amputation was advised by consultants, but action was deferred to see the effects of the other treatment. Serum and x-ray therapy were administered. No amputation was necessary and the patient was dismissed after seven weeks' hospitalization.

Case 2. J. B., schoolboy, age 10 years, entered the hospital on Aug. 24, 1930. He had been injured by stepping on a nail, which penetrated deeply into the tissues of the left os calcis area. Antitetanus serum was given immediately. Two days later the wound had the appearance, odor, etc., of gas gangrene; cultures of the wound were positive for *Bacillus welchii*. X-ray treatments were started after amputation had been strongly advocated by several consultants. The patient improved rapidly and no amputation was necessary. He was dismissed after three weeks' hospitalization.

Case 3. K. B., laborer, age 23 years, entered the hospital on Nov. 15, 1930, following an injury while blasting with dynamite. Some had exploded prematurely, and the

face, right arm, and left leg were badly injured, and the right hand was missing. The debris at the lower part of the right forearm received surgical attention and tetanus antitoxin was given. Two days later, cultures of the wounds in the left leg area were positive for *Bacillus welchii*. Gas bacillus serum was administered and x-ray treatments were given over the left leg and the stump of the right arm. The patient recovered, with no further loss of extremities, and was dismissed after five weeks' hospitalization.

Case 4. C. H., merchant, age 42 years, entered the hospital on Jan. 8, 1931, with the bones of the left leg shattered by a bullet wound just below the knee. Cultures from the wound showed positive *Bacillus welchii* infection, and x-ray films showed considerable gas in the soft parts. Serum was given. The leg was disarticulated at the knee, but the infection progressed up the limb, and all the tissues to the hip were swollen, crepitant, and discolored at the time the first x-ray treatment was given. Improvement began with the x-ray treatments and, four days later, the patient was free from evidence of active gas bacillus infection. He was dismissed after eight weeks' hospitalization.

Case 5. This record was secured from a nearby hospital. The patient, who did not receive x-ray treatment, died. The man, who was 51 years of age, was admitted to the hospital on Feb. 2, 1931, suffering from a compound fracture of the os calcis. A prophylactic serum against tetanus and gas bacillus was administered and local surgical measures were immediately used to clean up the wound. On February 6, there appeared to be a gas bacillus infection present; the laboratory report confirmed this opinion. Immediately 100 c.c. of regular serum were given intravenously. At each 12-hour interval thereafter, he received a dose of 10 c.c. of concentrated serum, totaling 50 c.c. con-

centrated serum in addition to the prophylactic dose. The patient received no x-ray treatment. He died 56 hours after admission to the hospital, in spite of these surgical and serological measures.

In this case a prophylactic dose of serum was given, in addition to thorough local surgical measures at the time of the injury. During the progress of the disease the case was handled by an orthopedic surgeon with considerable experience in treating this infection during the World War. The fatal termination should impress upon us that any help we are able to secure in a fight against this infection should be welcome.

Case 6. C. H., age 61 years, was admitted to the hospital on April 1, 1931, suffering from an injury to the left ankle area when he fell from a tractor. Clinically there appeared to be a gas bacillus infection present. The laboratory report was positive for *Bacillus welchii*. Amputation was immediately performed and serum administered, but apparently the infection was not entirely checked, and a second amputation was performed. After the second amputation, roentgentherapy was used and the patient recovered. He was dismissed after six weeks' hospitalization.

Case 7. H. B., age 82 years, was admitted to the hospital on April 14, 1931. The patient, who presented a strangulated hernia, was immediately operated upon. On April 20, complications suggestive of gas bacillus infection were noticed, after the patient had apparently rallied from the operation and was on his way to recovery. Cultures taken from the wound showed gas bacillus infection. Gas bacillus serum was immediately administered. Many other general measures were used in addition to the serum, but the patient died. He had received no x-ray treatment.

Case 8. The history on this case is incom-

plete, as only a few facts were given to the writer by the attending surgeon. A boy, age 6 years, who lived in the country, fell on June 1, 1931, and received a compound fracture of the bones of the forearm. Gas bacillus infection set in and the arm was amputated as soon as the diagnosis was made. The patient lived. No x-ray treatment was given as the surgeon stated emphatically that he had never heard of such a thing. This man is a surgeon, not a general practitioner who does surgery. He stands very high in his community, is a member of the strongest surgical association in this country, and is the chief of a surgical staff in one of the largest hospitals in Nebraska. He has no objection to using the x-ray in such cases if he thinks it will do any good. The value of the x-rays in localized infections is apparently not as well known as the radiologist believes, and this must be the radiologist's fault.

Case 9. J. F., age 8 years, entered the hospital on June 18, 1931, following a compound fracture of the left forearm. When he was admitted to the hospital two days after his injury the laboratory report was positive for *Bacillus welchii* and the x-ray films showed some gas scattered through the soft tissues about the fractured bones. Consultation was called and amputation advised. The use of serum and x-rays, at least temporarily, was decided upon. The boy immediately improved and amputation was not necessary. He left the hospital after a severe serum reaction, which caused considerable discomfort.

TECHNIC

The technic of the treatment used in Case 4 is stated below as the patient was one of the most seriously sick individuals of the group and the response was typical.

He entered the hospital on Jan. 8, 1931,

and x-ray treatment was started on January 12, using the following factors:

Mobile x-ray unit: 5-30 radiator type of tube
5-inch spark gap (approximately)
5 milliamperes
15-inch distance (approximately)
0.5 millimeter aluminum filter
3 minutes over each area treated, operating the tube 30 seconds, allowing it to cool for 30 seconds, and repeating this procedure until the full time was given.

January 12, morning	left femur, anteriorly	3 min.
January 12, afternoon	left femur, anteriorly	3 "
January 13, morning	left femur, anteriorly	3 "
January 14, morning	left femur, anteriorly	3 "
January 14, morning	left femur, posteriorly	3 "
January 15, morning	lower femur	3 "
January 15, morning	upper thigh and groin	2 "

No other case received as much dosage as this one. Most of them received 3-minute doses twice the first day, twice the second day, once on the third day, and once again on the fourth day, with the other factors as stated. All tissues suspected of involvement should be irradiated. If it is not possible to cover them at 15-inch distance (no cone), the tube should be moved and some overlapping on the areas allowed. Care should be taken that the filter is not left out. There should be no danger from the above dosage.

THE ACTION OF THE RAYS

Any attempt to explain the action of the x-rays in treating localized infections necessitates a consideration of the fundamentals of the useful characteristics of the x-rays. Briefly, they are:

1. They are capable of penetrating objects opaque to ordinary light. The ability to penetrate is in inverse proportion to the density of the object (physical action).
2. They are capable of causing a chemical change in the emulsion of an unreduced photographic film (chemical action).
3. They are capable of causing fluorescence by striking certain crystals (physical action).
4. They are capable of exerting a stimu-

lating or destructive action on living cells, depending upon the amount of radiation received (biologic action).

5. They are capable of rendering gases conductive to electricity (ionization—physical action).

The power of the rays to penetrate the tissues may be of value, as we are attempting to reach a living organism or its toxins situated deeply in the muscles.

The second characteristic is the power of roentgen rays to cause chemical changes. It may be that some chemical changes take place in the tissues which render them unsatisfactory hosts to the anaërobic saprophytic, etc., organisms, which require a particular type of surroundings for existence.

The third characteristic mentioned is the power of x-rays to cause certain crystals to fluoresce. Since the organisms are unable to tolerate air (anaërobic) is it not possible also that they do not tolerate a wave length such as that of the roentgen ray, which may in itself be harmful? Or may the rays be changed by some substance in the tissues (as they are changed in the case of fluorescence) to produce a wave length of such a nature as to be inhibitory to the welfare, or possibly even destructive, of the organisms?

The fourth characteristic is the power of x-rays to cause a biologic action when they are directed on living cells. One may think of several ways in which this action may be of value in the problem we are considering, but much work must be done before the correct solution is obtained. The ray, acting in a destructive capacity, may kill the organisms themselves, or it may act as a bacteriostatic and, by preventing their propagation, bring their biologic course to an end. On the other hand, when it is acting in a stimulating capacity the beneficial action of the roentgen ray may be on the cells of the host, stimulating them to superior defensive powers which, in the end, eliminate the invading organism. Many variations or combinations

of the above-mentioned possibilities may be present. In this useful characteristic we have a high hurdle for our professional critics to take. They contradict themselves repeatedly and grossly here. When the radiologist recommends x-ray treatment for gas gangrene or some other type of infection, for instance a carbuncle, he is promptly told by the surgeon that the x-rays have no action in such matters, that they have no power to destroy any organisms. Shortly afterwards, this same practitioner may be overheard explaining to a patient that to take roentgen treatment for a certain condition is to incur a very serious risk as the x-rays are sometimes followed by considerable destruction of tissue; in other words, an x-ray burn may result.

The biologic action, that is, the ability of x-rays to exert a stimulating or destructive action on living cells, depending on the amount of radiation received, is a scientific and clinical fact beyond any possibility of question.

There is no claim made here that these organisms are destroyed by the use of x-rays or even that the rays act as a bacteriostatic. In fact, no claims are made. Some possibilities are mentioned and, at the same time, the inconsistencies of some of the objections to the use of the x-ray in the treatment of infections are pointed out. The dishonest practitioner claims it will not harm even a bacterium in one instance; he then explains to a prospective patient how powerful it is and what great harm roentgentherapy would surely do if it were tried in the next instance. At any rate, the writer has had an opportunity to treat a few cases of gas gangrene, after having been solemnly assured by some of the consultants that it would do no good. All the patients lived, and in no instance was amputation of a limb required from the effects of gas bacillus infection after the x-rays were used.

The fifth characteristic is the power of

the roentgen ray to ionize or split gases. Possibly the gas formed in the tissues in this disease may be highly toxic in its original state and the rays may, through some oxidizing effect, render the gas less toxic to the host or even destructive to the organisms which produced it.

To report at any further length on these nine cases would lead to much useless repetition. Summarizing from the data mentioned above, and from the hospital records, the following facts stand out:

1. All of the patients in the series had open wounds, all had active gas bacillus infection clinically, the laboratory reported positive cultures of gas bacillus, and all were seriously ill. There were from three to six physicians in consultation on every case. In the majority of cases, gas was scattered through the tissues, but not all of the patients were roentgenographed.

2. X-rays were used as an aid to treatment in six of these nine cases. Six cases recovered without the loss of any structures other than those lost prior to the use of x-rays or incident to the original injury. Of the remaining three cases, in which x-rays were not used, two died in spite of the usual serologic and surgical measures. In Case 8, though the patient lived, he lost one arm at the shoulder.

3. Many other therapeutic measures were also used in all the cases, and in none were the x-rays used as the only form of treatment. On the whole, the line of treatment varied according to the character of the original injury. The two patients who died had surgical and serologic methods used in their behalf. The patient with a compound fracture of the os calcis (Case 5) received a prophylactic dose of gas bacillus and anti-tetanus serum before the evidence of infection appeared.

4. The ages of the individuals, all males, varied between 6 and 82 years.

CONCLUSIONS

Roentgen rays are established aids in diagnosis and in teaching (including research), but it is in connection with their status as an aid in therapy, especially in connection with the treatment of gas gangrene in conjunction with other measures, that this article has been written. Furthermore it is sincerely hoped that the widespread use of them in many cases will be as generally successful as it has been in the few cases reported here. If so, there will be fewer amputations and transfusions, a lower mortality, and, probably, the use of less serum, which sometimes leads to severe reactions and much discomfort.

ADDENDA

Since this article was written, three more cases have been treated, but with two deaths. All cases received the benefit of surgical and serologic measures, as well as roentgen-therapy. In the two patients who died, the trunk was involved while in the one who recovered the upper extremity was involved. The postmortem findings in one case may give the radiologist an idea of the treatment of these cases involving the trunk, as the pathology was undoubtedly too deeply seated for the light dosage used. Henceforth, cases in which the trunk is involved will be transported to the x-ray department, in which the use of heavier voltage and heavier filter will insure a greater depth effect of the radiation.

CASE REPORT

Case 10. M. C., male, white, age 55 years, was admitted to the hospital on Aug. 19, 1931, and died August 24. Autopsy was performed one hour after death.

Anatomic Diagnosis.—Left ischiorectal abscess with a complicated gas gangrene infection extending below the levator ani into the perineum, scrotum, penis, and lower abdominal wall, and posterior to the rectum

upward over the brim of the pelvis. The infection spread out like a fan and extended above the psoas muscles up into the right kidney fossa, across the vertebral column, and over the anterior surface of the left psoas muscle. There were acute hyperemia of the lungs, congestion of the liver and spleen, sclerosis of the coronary arteries, slight arteriosclerosis of the aorta, and post-mortem discoloration of the dependent portions of the body.

Comment.—From the above summary, it is evident that the light dose of x-rays applied over the lower abdominal region and buttocks would fall far short of having any effect on an infection which had already extended upward into the kidney fossa and crossed to the other side anterior to the psoas muscle. The findings indicate only that, if the trunk is involved, heavier radiation should be employed before any conclusions are drawn as to the value of roentgen-therapy in gas infections.

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DISCUSSION

DR. W. A. JOHNSTON (Dubuque, Iowa): This paper is of unusual interest to me due to the fact that it adds one more inflammatory disease to the list of those which are benefited by x-rays. Dr. Pfahler stated that in 1906 he treated by x-rays a patient suffering very severely with arthritis and obtained improvement. I think that is about the earliest record we have of any inflammatory treatment by x-rays, although there may be earlier ones. In 1918 or 1920, Dr. Hickey did a great deal of work in treating diphtheria carriers with x-rays, reporting remarkable success.

However, as a whole, progress in our treat-

ment of inflammatory conditions, roentgen-therapeutically has progressed very, very slowly. There have been many ups and downs, partly due, I think, to the fact that we have had no scientific way of proving what the action of the x-rays is in the inflammatory tissue, and we are still dealing, in great part, with theories.

There are a few conditions, however, that survive all of the criticism that has been offered during this interim. I think we will all agree that there is improvement in the treatment of acne and boils; also that erysipelas is improved by exposure to x-rays. Dr. Langer has spoken of the marked improvement in the arthritic condition he is obtaining by the roentgen treatment of the vegetative nervous system.

Only a few weeks ago, Dr. Grant, from Rockford, Illinois, told me that he was obtaining much improvement in treating trifacial neuralgias by exposing from each direction the region of the gasserian ganglion. Of course, that probably would be an effect similar to the one Dr. Langer reports in his treatment of arthritis. In other words, it seems that we are returning to our position of some 10 or 15 years ago, and these cases are being reported because actual results are being obtained.

Dr. Kelly has told us of the improvement, or rather cure, that he has obtained in cases of gas gangrene. I do not think that Dr. Kelly needs to apologize in any way for reporting only six cases treated. I do not know whether I am wrong or not, but I do not believe there are more than two or three other men in the United States who have seen as many as six gas gangrene cases within a period of three or four years. In my experience at the University of Michigan, and in my present practice—we have a moderately large industrial practice and a large community of farmers—I have seen only one gas gangrene infection. There are undoubtedly some who have seen more, but I do think it is a remarkable record to be able to bring us a report of six cases treated; and especially six cases which have been treated successfully.

You who have seen these gas bacillus in-

fections realize that you are dealing with something almost as serious as cutting the aorta in nephrectomy. You practically throw up your hands and say there is absolutely nothing that can be done. In 1918, Dr. Bull had success in making a serum which was effective in the treatment of gas bacillus infection, but he reported that bacillus of malignant edema was nearly always present when *Bacillus welchii* was present.

I think that Dr. Kelly's paper is most timely. If he had reported it sooner, he might have done something more in saving the three patients who died, because the physicians in charge undoubtedly did not know the value of roentgentherapy.

DR. C. S. BUCHER (Champaign, Ill.): I would like to ask the essayist regarding the voltage. My understanding is that he uses a very long wave length. We have done some work, as a great many others have, with bacteria in culture media. We find that we can expose the culture media to short wave lengths or long wave lengths; we can give large doses or small doses, yet the bacteria still grow.

However, in living tissue, we do get results. We have cured quite a few cases of carbuncles, boils, and other infections. Recently we treated a few cases of infections of the upper lip and nose with very good results. Dr. Clark, of the University of Illinois, says the effect in the tissue is due to ionization. Of course, if we figure on the effect of electrons in living tissue, we will probably have a different result there than we obtain in culture media. Someone has suggested planting the bacteria in ordinary meat and letting them grow, then using x-rays to get results. I do not know how true that is, but I am going to try it.

There is one way of conveying this information to the general practitioner, and that is through the medical journals the general practitioner reads. I have had the opportunity, just recently, to write a few papers for one of the medical journals that is not read exclusively by radiologists. However, it is read by the general practitioners, so I address them.

DR. KELLY (closing): Gas gangrene seems to be on the increase in our neighborhood, not only in St. Joseph's and St. Catherine's hospitals, but in the neighboring hospitals as well. I do not know whether it is because we are looking for it and find it oftener, or just what is the reason. But I do not see how anybody could miss the cases we saw. They announced themselves, as you could smell them in the hall, and the cultures were positive in all.

Although I did not see these cases in their early stages, they developed fast. Our x-ray department is like any other—we get to treat cases when the rest of the staff wants to step aside.

Dr. Johnston brought up the question of early report on this work. I did feel quite badly about the six-year-old boy losing his arm, as he was from a town only 60 miles away and an earlier report might have prevented the amputation.

The voltage used is ridiculously low, but the only thing with which I could reach the patient was the mobile unit. It is a regular 5-30 unit with a small radiator tube attached, so the voltage used is about 80 kilovolts.

I believe I answered the question of ionization in the body of the paper. The part ionization plays in therapy is, of course, questionable. As I do not know what happens, I have answered questions in various ways, giving different reasons, because the more the question is argued, the better I like it. I have no more idea of what happens than some others do and for that reason I have encouraged discussion from every possible angle.

In regard to the diagnosis, I thought in my conclusion I reported that the majority of the cases had gas scattered through the tissue, but there were two which were not radiographed. All cases had positive laboratory diagnoses made by two men who had seen service during the last year in France and were familiar with gas gangrene, Dr. F. W. Niehaus, of St. Catherine's, and Dr. B. Carl Russum, at St. Joseph's.

As to the question brought up on voltage. Get me straight on that: I think the low volt-

age is all right in the cases in which the infection is localized in the extremities, but I lost one with trunk involvement at the County Hospital and one with trunk involvement at St. Joseph's Hospital and I felt it was because I did not use enough voltage. I am satisfied that higher voltage is necessary in trunk involvement, but I do not know its exact status.

DR. C. E. PIERSALL (Reno, Nevada): The doctor did not say a word about making a roentgenographic diagnosis of these cases. That was brought out at the Los Angeles meeting last year, at which there was a nice display.² I think it is opportune to ask the Doctor if he found characteristic signs on the x-ray films in all these cases, or if he used the roentgen ray to diagnose gas gangrene. In the last four or five months, I have had two cases that we diagnosed roentgenographically before they were diagnosed otherwise. I believe that it can practically always be done very early.

DR. GAGE CLEMENT (Duluth, Minn.): In case of accident, how do you differentiate on your x-ray film between gas gangrene and subcutaneous emphysema?

DR. PIERSALL: Others can give you more information on that. But I see the bubbles entirely away from the punctured wound, located between the tissues, sometimes, in both directions from the wound.

DR. D. A. RHINEHART (Little Rock, Ark.): It was my brother who read the paper mentioned by Dr. Piersall. He and I worked this problem out together.

The agricultural regions of Arkansas, around Little Rock, seem to be filled with this bacillus, as well as the bacillus of anthrax. In Little Rock, we had a number of these cases. We have four hospitals on our visit-

ing list there and we see these patients two or three times a month. In two different hospitals we discovered this gas dissecting itself along the muscle and tissue planes spontaneously. We compared notes on them and finally collected this clinical material that was exhibited at Los Angeles, which formed the subject for the paper.

The diagnosis is very easy, providing always that the films are of good quality. I allowed a technician to make a film of an open wound in a patient; however, the film was overexposed. Later, in collecting the clinical material, we reduced the film with reducing solution, and found bubbles of gas in the muscle planes which I had missed in the first place because of the over-exposure.

The bubbles are very easy to see. In any case in which there is gangrene, they will occur within from 6 to 24 hours. The diagnosis can always be made by roentgenographic examination much quicker than by any other method before the patient really has any clinical symptoms, or there are clinical findings.

Although we see so many cases of it, we have had no experience in the treatment of gas gangrene. If there is any place in the country in which x-ray treatment should be of great benefit, if it is as good as Dr. Kelly says, that place is Arkansas.

DR. W. L. ROSS (Omaha, Neb.): I wish to confirm the diagnostic value of x-rays in this lesion. Dr. Kelly will recall that, perhaps some six or seven years ago, Dr. Tyler had occasion to demonstrate the peculiar air lines which stand up like air in any other part of the body, dissected up alongside the muscles. They are characteristic from the diagnostic standpoint. I have had experience in only one case, five or six years ago, and obtained the same findings. The air line could be very readily seen dissecting in between the tissues and up along the muscles. I am sorry to say that I did not get a chance to treat the patient, although I suggested the idea.

²Rhinehart, D. A.: Air and Gas in the Soft Tissues: A Radiologic Study. *RADIOLOGY*, December, 1931, XVII, 1158-1170.

RADIUM IN MEDICAL USE IN THE UNITED STATES¹

By R. R. SAYERS, M.D., Chief Surgeon, U. S. Bureau of Mines; Surgeon, U. S. Public Health Service, WASHINGTON, D. C.

RADIO-ACTIVITY, the property of radium that led to its isolation more than thirty years ago, is the characteristic that makes it of value in the treatment of disease. Tyler² gives the following brief history of the investigation:

"The way to the discovery of radium was opened in 1895 by Roentgen, who found that the glow from a Crookes tube contained penetrating rays, which he called x-rays. Prof. Henri Becquerel, while investigating the effect of various phosphorescent substances, found that uranium salts produced photographic impressions even when enveloped with opaque substances. To Marie Sklodowska, a young Polish student, who later became Madame Curie, Prof. Becquerel delegated the task of learning how and why uranium possessed power to emit these peculiar rays, which he had proved to be electrical in character. Madame Curie, examining by electrical methods the radio-activity of a large number of minerals containing uranium and thorium, discovered that some specimens of pitchblende had about four times the activity of the metal uranium; that chalcocite, the crystallized phosphate of copper and uranium, was twice as active as uranium; that autunite, a phosphate of calcium and uranium, was quite as active as the same weight of pure uranium. In order to check these discoveries, she prepared chalcocite artificially, starting with pure products, but found that this artificial chalcocite had only the activity represented by its composition, or, roughly, 40 per cent of the activity of uranium. This led to the conclusion that there was some element or substance in the residue from uranium minerals that possesses a high degree of activity. After an exhaustive chemical investigation of pitchblende from Joachimsthal, she found that this mineral contained

not only uranium but also another radio-active substance, to which she gave the name of polonium, in honor of her native land. Later in 1898, Monsieur and Madame Curie found still another element, which, when brought to a state of concentration, was several million times as active as uranium, and to this was given the name of radium. Debierne afterwards found a fifth radio-active substance, actinium, and in 1906 Boltwood isolated the metal ionium. Strictly pure radium chloride was first produced in 1902."

The first radium was produced commercially from the uranium residues obtained from the mines of Joachimsthal, Bohemia. Tyler calls to attention that, as the ores were a government monopoly, search was begun at once for sources in other parts of the world. As a result, radium-containing ores have been found in about ten countries.

The interest of the Bureau of Mines in the efficient recovery of radium extends back to about 1912. Under an agreement with the National Radium Institute³ the Bureau built and, in June, 1914, began the operation of a radium-recovery plant at Denver, Colorado. By the time the work ceased in January, 1917, 8.5 grams of radium had been produced. The methods devised by this investigation reduced the cost of recovering radium to about one-third of the then current prices. F. L. Hess, principal mineral technologist of the Bureau of Mines, states⁴ that at the present only two countries are producing significant quantities of radium—the Belgian Congo at Chinkolobwe, Katanga, and Czechoslovakia at Jachymov (formerly St. Joachimsthal). In 1922 there was an important development in

¹Reprinted from U. S. Bureau of Mines Information Circular 6667. Read before the Seventeenth Annual Meeting of the Radiological Society of North America, at St. Louis, Nov. 30-Dec. 4, 1931.

²Tyler, Paul M., Radium. Inf. Cir. 6312, Bureau of Mines, 1930, 55 pages.

³The National Radium Institute (Inc.) was a corporation organized and existing under and by virtue of the laws of the State of Delaware for the study of the best methods of producing uranium, vanadium, and radium.

⁴This statement is contained in a chapter prepared for publication in Spurr and Wormser's "Marketing of Metals and Minerals."

the radium industry by the opening in that year of the radium works of the Société Metallurgique de Hoboken at Oolen, in Belgium, which soon acquired a monopolistic position. The material treated in these works was obtained from the Belgian Congo through the Union Minière du Haut Katanga. In the concessions of this company, which is primarily copper-producing, radium-bearing ore was discovered at Luiswishi in 1913 and at Chinkolobwe in 1915. . . . The present productive capacity of the Oolen works is about six grams of radium monthly. At present, the price fluctuates between sixty and seventy dollars per milligram (£12 10s. to £15), or in the region of 270 marks.⁵ These two countries now produce annually about sixty grams and three and a half grams, respectively. Besides these, seven other countries have radium deposits which, in order of size of the known deposits, are about as follows: United States, Canada, Russia, Portugal, Madagascar, England, and Australia. It is possible that the position of the first-named countries may be reversed before another year has passed. The deposits discovered in 1930 on the east side of Great Bear Lake, District of Mackenzie, Canada, are said to be the richest and possibly the largest yet found.⁶ From prospecting operations during 1931, 20 tons of pitchblende were obtained and shipped. The extractions that have been made from batches of this ore have been well over 90 per cent. The 20 tons is said to contain at least \$100,000 worth of radium at present prices.

During the past few years, the amount of radium used for medical purposes has been much discussed. In Great Britain plans for distributing and supervising the supply of radium for treatment of disease have been completed and put into effect. The first an-

nual report⁷ states that the National Radium Trust has as its chief duties: To take charge of funds raised by public subscription and voted by Parliament for the provision of radium and to arrange for the purchase of radium. The Radium Commission has the duty of making the arrangement for the proper custody, equitable distribution, and full use of the radium purchased by the Radium Trust. The Radium Commission is composed of ten members and a chairman. The Trust appoints the chairman. The Minister of Health, the Secretary of State for Scotland, the Medical Research Council, and the Department of Scientific and Industrial Research severally appoint one of the members. The remaining six members are selected by the Trust from a panel of not less than 12 persons having special knowledge and experience in the application of radium in the treatment of the sick. Up to August, 1930, the National Radium Trust had ordered 18.5 grams of radium. Of this amount, some 18 grams had been provisionally allocated to national centers; only 14 grams had been received from the radium manufacturers, and not more than 8 grams had been actually delivered to the centers. In France⁸ the Government has established 15 radium centers in various parts of the country, and allocated to them 31.5 grams of radium (in addition to about 20 grams believed to be privately owned). In Sweden⁹ the use of radium is highly organized under Government auspices. A strong movement was started in 1929 to acquire a larger supply of radium in England, where a governmental committee recommended that 24 grams be acquired in addition to about 25 grams then available in the British Isles.

"The federal commission [in Germany] for the control of cancer summoned experts recently to discuss the question of the purchase and distribution of radio-active substances such as radium and mesothorium. As a re-

⁵Belgian Radium Industry. Canadian Min. Jour., June, 1932, pp. 255, 256.

⁶Goodwin, W. M., Mines Branch Radium Plant. Canadian Min. Jour., June, 1932, pp. 253-255.

⁷National Radium Trust and Radium Commission, First Ann. Rep., 1929-1930, London, 1930, 74 pages.

⁸See Ref. 2.

⁹See Ref. 2.

sult, the Deutsches Zentralkomitee zur Erforschung und Bekämpfung der Krebskrankheit and the Reichausschuss für Krebsbekämpfung agreed on certain criteria, which are set forth in a communication by Professor Friedrich: The purchase of radio-active substances should be considered only by such institutions as have an experienced radiologist for the therapeutic application of such substances. The use of small quantities of radio-active substance for the local treatment of carcinomas is the method indicated by the present status of medical knowledge, whereas the treatment *à distance* with heavy doses of several grams is a method concerning which no definitive opinion can be given as yet. Supplies of radio-active substances should be available in all university clinics and large hospitals, the amount ranging from 200 to 500 milligrams, according to the population of the area for which provision is made. Some centers should have an additional amount in order that they may serve also as research centers. Such central institutes should have an average of 50 milligrams of radio-active substance for each bed designed solely for patients to be irradiated. A central institute should have not less than twenty beds set apart for the use of cancer patients to be irradiated with radio-active substances, which presupposes accordingly the possession of 1,000 milligrams of radio-active substance. Since experience has shown that the biologic effects of the rays emanating from radium and mesothorium are of equal value, in the purchase of supplies the choice as between radium or mesothorium should depend exclusively on economic and practical considerations. The legal regulation of the application of radio-active substances for therapeutic purposes is a problem of the near future."¹⁰

In the United States, from the time that American radium factories made the first production of radium salts in 1913 to the last recorded output in 1926, they isolated about 203.3 grams of radium. Besides this production the imports of radium (Table I) in salts are shown by the customs records.

It is thought that at least 3 grams were imported previous to 1923, at which time Belgian radium began to arrive in this country. Production and imports are shown in Table I.

TABLE I

Year	Radium produced in U. S. grams	Radium imported into U. S. grams
1913	2.1	-----
1914	9.6	-----
1915	4.71	-----
1916	8.17	-----
1917	13.83	3.00 estimated
1918	22.79	-----
1919	28.648	-----
1920	32.539	-----
1921	35.693	-----
1922	24.189	-----
1923	12.212	8.75
1924	3.365	8.1
1925	2.952	9.27
1926	1.725	10.97
1927	none	7.26
1928	none	10.97
1929	none	10.69
1930	none	16.86
Total	202.523	85.87

The total production and imports into this country to the end of 1930 have been in the neighborhood of 288.4 grams. It is probable that since 1916, including use during the Great War, not more than an average of 2 grams per year has been used in luminous materials, a total of not more than 30 grams. What exports have amounted to is unknown, but they have probably not exceeded 20 grams, so that, making no allowance for broken tubes and other losses, there would appear to be still in this country 238 grams of radium. This is very much more than can be accounted for from holdings, and there may have been much larger exports than have been recorded.

The amount of radium in the United States now used for medical purposes has been variously estimated at from 50 to well over 200 grams. The following statement was published in the *Journal of the American Medical Association*.¹¹

"According to figures supplied by the

¹⁰Purchase and Distribution of Radio-active Substances. Jour. Am. Med. Assn., Oct. 3, 1931, XCVII, 1016.

¹¹Radium Owned by Hospitals and Physicians. Jour. Am. Med. Assn., June 13, 1931, XCVI, 2057.

American Society for the Control of Cancer, which are recognized to be only relatively complete, the total amount of radium owned in quantities of 75 milligrams and over in the United States is 85,228 milligrams. The hospitals owning 75 milligrams and over number 135. The 135 hospitals own 68,033 milligrams. The individuals owning 75 milligrams and over total 47, with a total of 6,945 milligrams."

The United States Bureau of Mines recently sent out to all the hospitals listed in the 1931 Directory of the American Medical Association the following letter and questionnaire, A and B:

(A)

"The Bureau of Mines is asked repeatedly as to the need for additional radium in the United States. The question naturally arises as to how much is now available, the number of people receiving treatment, and the total number of treatments needed.

"In order to more accurately supply this information, the inclosed questionnaire is being sent to the principal hospitals in the United States. I would very much appreciate it if you would have this form filled out as completely as possible and returned at once in the inclosed franked envelope.

"Yours sincerely,

(Signed) R. R. SAYERS,
Chief Surgeon, U.S.B. of M;
Surgeon, U.S.P.H.S.

(B) RADIUM—FOR MEDICAL USE

- "1. How much radium (element) have you on hand.....grams.....milligrams?
- "2. Please show below quantity of radium in each salt:

Salt	Grams	Milligrams
Bromide
Sulphate
Chloride
Carbonate
Other (please specify)

- "3. Date when acquired.....
- "4. Please show below quantity of radium in each form:

Form	Grams	Milligrams
Applicators
Needles
Tubes
Solution

- "5. Number of patients treated annually.....
- "6. Total number of treatments.....
- "7. If you do not have radium, how is radium treatment obtained for patients in your hospital or in your vicinity who need such treatment?.....
- "8. What is the usual price paid per milligram-hour by your hospital or by individuals to institutions or persons furnishing radium treatment?.....
- "9. Are these arrangements satisfactory to your institution?.....
- "10. How much more radium could you use to advantage?.....
(This question is intended only to give the United States Bureau of Mines an idea of the country's need for more radium.)
- "11. Do you know of physicians outside of hospitals having radium in your city? If so, please give names on reverse of this sheet.

(Please sign here)

(Official title)"

To date, 287 hospitals and clinics have reported that they have a total of 85,800.26 milligrams of radium, and 128 of the 287 each had 75 milligrams or more; 414 physicians have reported that they have 33,286.93 milligrams and 171 of the 414 each had 75 milligrams or more; nine laboratories and companies have reported that they have 5,545.42 milligrams and five of the nine each had 75 milligrams or more. New York, as would be expected, had the largest amount — 29,800.61 milligrams; Pennsylvania had the next largest amount—12,902.21 milligrams. Five States reported no radium in hospitals, and, according to the reports received, no radium is owned in one State (Wyoming).

All of the reports did not designate the kind of salt in which the radium was held. Those reporting, however, gave the following quantities:

	Milligrams
Bromide	24,676.44
Sulphate	49,939.23
Chloride	17,047.11
Carbonate	169.01
Other	1,119.64

The quantity of radium in each form, as shown by the reports, is as follows:

	Milligrams
Applicators	4,186.60
Needles	42,369.63
Tubes	35,223.79
Solution	26,027.65

From the reports it is estimated that the number of patients treated annually with radium is approximately 80,000. Individuals, companies, and hospitals to the number of 710, owning 124.7 grams of radium, estimate that they need 117.4 grams more. It has been suggested that the amount needed might be estimated from the number of persons who could be benefited by radium treatment. As any statistics for such an estimate are limited, it seems best to consider only malignant newgrowths and to neglect the 25 or 30 other conditions which, at least in selected cases, are benefited by radium.

In 1900 when the registration area was first formed, the crude death rate from cancer was 63 per 100,000 population. In 1920 it was 83.4, and in 1929 (the latest available figures) it was 96.1, an increase over the crude death rate of 1900 of nearly 52.5 per cent. In 1929 the total number of deaths from cancer was 111,569. This makes cancer the second most important cause of death. Heart disease alone, with 245,000 deaths, claimed a greater number of victims. One of the most striking increases in the death rate has been in the so-called external forms of cancer, such as cancer of the breast

and cancer of the mouth, in which, because of the superficial position, errors in diagnosis are low as compared with the possibility for error in deep-seated cancer such as that of the stomach or other internal organs.¹² Hess, using these cancer mortality statistics as a basis, estimates that "at least ten times as much radium could be used advantageously as seems to be held in this country at present."

SUMMARY

Radium was first produced commercially from residues of uranium from the mines of Joachimsthal, Bohemia. Radium-producing ores have been found in about ten countries.

The United States Bureau of Mines devised methods of recovering radium which greatly reduced the cost. The plant operated by the Bureau of Mines from June, 1914, to January, 1917, produced about 8.5 grams of radium.

Up to 1926, 202.5 grams of radium have been produced in the United States; none has been produced since that date. Radium to the amount of 85.87 grams has been imported into the United States, chiefly since 1923.

It is estimated that 2 grams per year, or a total of 30 grams, have been used for luminous materials.

In about 83 per cent return on over 6,600 hospitals and clinics in the United States, 287 report having 85.8 grams of radium; 128 hospitals and clinics each have 75 milligrams or more; 414 physicians report having 33,286.93 milligrams, and 171 physicians each have 75 milligrams or more; 9 laboratories and companies report having 5,545.42 milligrams, 5 of which each have 75 milligrams or more. New York State reported 29,800.61 milligrams. No radium was reported from one State (Wyoming),

¹²These figures are quoted from *Health News*, issued by the U. S. Public Health Service on Oct. 13, 1931.

and no radium was reported in hospitals from 5 States. Seven hundred and ten individuals, companies, and hospitals, owning 124.7 grams of radium, estimate that

they need 117.4 grams more. From the reports, it is estimated that approximately 80,000 patients are treated annually with radium.

INDICATIONS FOR IRRADIATION IN INTRA-UTERINE BLEEDING¹

By JOHN H. VAUGHAN, M.D., AMARILLO, TEXAS

IT is safe to say that, when a case of uterine bleeding presents itself, a large percentage of our physicians give medicines, without an intensive examination, in the hope that the bleeding will stop. If it does not, the patient is subjected to the inconvenience, pain, and expense of a dilatation of the cervix and curettement of the uterus. This may correct the condition. If it does not, the patient is advised that a hysterectomy must be done, and, in a great percentage of cases, she accedes rather than to continue bleeding.

Radiologists, knowing the advantage of irradiation over surgery in most of these cases, should continue to talk about it so that the average physician will not condemn his patients to surgery, with unnecessary suffering, extra expense, prolonged convalescence, unsatisfactory end-results, and even death. Every honest physician and surgeon is interested enough in his patients to want them to have what is best. Radiology is not old enough for its indications to be well understood by physicians who have not had sufficient contact with cases treated by irradiation to observe the results.

Radiology certainly should be considered an adjunct to surgery, and not a competitor. In my opinion, a man who has done considerable surgery of the pelvis should be more capable of stating the indications for, and application of, radium there. However,

he should not consider himself capable of applying radium just because he is a surgeon. Neither should he attempt to treat cases amenable to irradiation through the instructions of some concern which rents out radium and gives as a bonus the instructions in the case. It would be as reasonable for a druggist to try to treat a case of pneumonia through the instructions of a physician at some remote point.

One of the most common causes of radium being brought into disrepute is the mistakes made by men untrained in radiology. If a physician is going to apply either radium or x-rays as a therapeutic measure, he should associate himself long enough with men of experience in this field to acquaint himself with the indications, reactions, and results of the rays. If he has no intention of applying the science of radiology himself, it behooves him at least to read enough along this line to have a well based idea of when to refer his patients to a radiologist, just as the internist must know when to refer his patients to a surgeon, or *vice versa*.

We are not mentioning in this paper the medical or surgical measures in uterine bleeding but are only trying to point out some of the more common conditions in which irradiation is indicated.

Some of the contra-indications for the use of large doses of radium and x-rays in pelvic cases, otherwise amenable to treatment by irradiation, are:

1. Acute pelvic infection.

¹Read by title at the Seventeenth Annual Meeting of the Radiological Society of North America, at St. Louis, Nov. 30-Dec. 4, 1931.

2. Patients under 35 years of age, unless the condition is malignant.

3. Pedunculated fibroids.

4. Uterine tumors larger than a four-months' pregnancy, or those causing considerable pressure, when the patient is a satisfactory surgical risk.

5. Marked anemia.

Pelvic Infection.—When massive doses of x-rays or radium are used in the presence of an acute pelvic infection or inflammation, the lesion will become more active and the patient may be very sick.

Young Women.—It has long been the consensus of opinion that the menopause should not be induced by any means before the patient is 35 years of age, except for malignancy or some other very urgent cause.

Pedunculated Fibroids.—It is evident that, if the rays cause a disintegration of the tumor tissues, and if the tumor is on a pedicle, the latter will undergo disintegration long before the mass of the tumor. The necrosed tumor remains loose in the abdomen, necessitating a hurried laparotomy.

Very Large Tumors.—If the pelvis is tightly filled with a tumor, or one is present that is larger than a four-months' pregnancy, and the patient is a good surgical risk, surgery should be employed, rather than irradiation. If the patient is not a good surgical risk, good results may be obtained in most cases by irradiation.

Marked Anemia.—Patients in whom the red cell count is under 2,500,000 should not be subjected to massive doses of radium or x-rays. An effort should be made to bring up the red cell count, if anemia exists. If the anemia is due to severe uterine bleeding, small doses of radium should be used to control hemorrhage, then larger doses as the patient is able to stand them.

SOME COMMON CONDITIONS AMENABLE TO IRRADIATION

Leukorrhoea.—In most intractable non-

gonorrheal cases, cure may be expected within about six months.

Menorrhagia and Metrorrhagia.—Irradiation of from 300 to 800 mg.-hrs. in the fundus will usually correct these conditions. Hypertrophic endometritis and so-called idiopathic bleeding may be corrected with approximately the same dosage.

Excessive Menstruation in Consumptives.—As a rule Nature takes care of these cases by stopping menstruation or making it scanty; however, there are some patients who bleed excessively at menstruation, with resultant weakening. In my opinion the menstruation should be suppressed by irradiation at least until the patient has become an arrested case.

Uterine Polypi.—The cervix should be dilated, the polypi removed, and from 500 to 800 mg.-hrs. of radium applied in the fundus. If the patient is past 35 years of age, it is probably best to give as much as 2,500 milligram-hours.

Large, Boggy Retroflexions.—If the patient is near the menopause and the condition is causing marked symptoms, relief may be given in a few months by the use of large doses of radium.

Uterine Tumors (Non-malignant).—Patients past 35 years of age should be given large doses of radium, if the tumor is causing symptoms and there are no contra-indications. If irradiation is contra-indicated, resort to surgery should be had. Irradiation is preferable to surgery in these cases because the pain is many times less, the cost is less, the convalescence is markedly shortened, and the end-result is more satisfactory. Surgery in these cases is at least twelve times more dangerous to the patient than irradiation.

Cancer of the Cervix.—It seems that the most doubting surgeons have at last been convinced that, in cancer of the cervix, surgery should practically never be resorted to.

Adenocarcinoma is the most radioresistant of the cancers, but even in it surgery does not seem so efficient as radium. In early cervical cancer, the uterine, cervical, and vaginal canals are the only areas in which the radiating substance is placed. However, if the cancer has metastasized, external radium or x-rays should be used.

Cancer of the Fundus.—Until recently surgeons and radiologists considered that a fundal cancer was best treated by combining radium and surgery. It seems that statistics are about to prove that it is best not

to perform any surgery, even in these cases, but to depend on irradiation.

As stated by Dr. J. C. Bloodgood, if there is a question of doubt, it is both theoretically and practically wiser to try irradiation first in most cases. Remember, however, that there are a few cases in which delayed surgery might be harmful.

We have not given statistics in this paper nor are we saying much about the technic of treatment. Many convincing statistics are available from our large clinics and hospitals.

BOOK REVIEW

LE REMANIEMENT NOSOLOGIQUE DE LA DILATATION DES BRONCHES PAR L'APPLICATION SYSTÉMATIQUE DU LIPIODO-DIAGNOSTIC (The New Classification of Bronchial Dilatations by the Systematic Application of Lipiodol Diagnosis). By POUMEAU-DELILLE. Preface by PROFESSOR EMILE SERGENT. Pages 132, with 27 illustrations. Masson et Cie., Editeurs, Paris, 1932. Price, 24 francs.

The use of lipiodol in diagnosis permits the recognition of the unexpected frequency of bronchial dilatations by showing up the characteristic images in the cases of non-fetid bronchorrhea. On the other hand, this method of study renders possible the differentiation of the pseudo-vomicæ of bronchial dilatations from the true vomicæ due to a pulmonary supuration.

The simple radiologic appearance, that is, without the aid of lipiodol, in cases of bronchiectasia is generally not highly characteristic, consisting of a more or less generalized or localized accentuation of the descending shadows of the lung tree. Sometimes the shadow of a retractile pleuropulmonary sclerosis suggestive of mediastinal pleurisy attracts attention and suggests the possibility of a bronchiectasis, to be confirmed by the use

of lipiodol. After the injection of iodized oil the shadows of beaded, ampullar, sac-like dilatations are characteristic of bronchiectasis. Certain shadows of displaced bronchi with puddling of lipiodol do not necessarily indicate the presence of bronchial dilatations; for instance, they may be due to pulmonary sclerosis with emphysema.

It is possible to recognize the radiologic aspects of bronchiectasis on the simple films by comparing films made before and after the injection of lipiodol; the dilated bronchi as a rule appear in the form of dark areas, while the clear adjacent areas suggesting cavities correspond to the healthy pulmonary parenchyma.

The foregoing are some of the conclusions drawn by the author from his work, which was done under the supervision of Professor Sergent. They crystallize the results of the last ten years in the clinic of the well-known investigator of pleuro-pulmonary roentgenology in his research on the application of the method of Sicard and Forestier to pulmonary disorders. This excellent little work is beautifully illustrated, much better than the average French publication. The text is amplified by an excellent bibliography and by detailed observations on 48 cases.

EDITORIAL

LEON J. MENVILLE, M.D. Editor
BUNDY ALLEN, M.D. Associate Editor

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Radiological Society of North America.*

THE EFFECT OF THE DEPRESSION ON RADIOLOGY

The depression has been the occasion for many members of the medical profession to lose a keen sense of justice in their relations with their fellow-practitioners. Some have suffered from an obsession of fear that they are in danger of, losing all their practice, with an accompanying financial loss, and that great harm was about to befall them. For this reason they became the worst pessimists of all. There could not be an optimistic future—all was hopeless! They became desperate and fearless. Many new combination cut-throat practices emanated from their disturbed minds. No amount of persuasion could make them see the light of wisdom and fair play.

Then, again, we have others, somewhat more optimistic, who admitted they could get along comfortably if only they were permitted to dictate the policies and practices of members of the medical profession—practices which would redound in financial benefits to themselves.

It is with pride we can say that the larger number of our noble profession have remained sane. They have taken their misfortunes with a smile, trusting that conditions will improve, ready and willing to cooperate with organized medicine for the best interests of all. Much praise is due these noble men who have remained untainted, unselfish, loyal American physicians.

In the very early beginning of the depression the medical profession was assailed for the high cost of medical care. After a cer-

tain amount of discussion and deliberation by a few, it was thought best to attack the financial policies of hospitals, and in a measure rightly so. It was generally agreed that if certain hospitals would separate themselves from their pet hobby, free clinics, they would then be able to run along satisfactorily and be able to reduce their overhead enough to offer some reduction in their rates. It was thought that this would perhaps prove satisfactory if put into operation. But the operating executives soon became apprehensive that this would not be sufficient to appease the dissatisfied ones, and began to search for some new way of "passing the buck." Ever since then we have heard talk of reducing the cost of laboratory work, and recently some have advocated reduction in the number of roentgen examinations in order to reduce the "high cost of medical care."

There has just appeared in a prominent medical bulletin an article written by an eminent American surgeon in regard to important matters concerned with the practice of medicine. In this article the author says that "during the last few months we have all learned that many of the mechanical tests can be dispensed with and that they need not be repeated. Fewer roentgen examinations are required. The depression may be beneficial, as far as medical practice is concerned, in re-establishing sound medical practice and emphasizing the value of the general practitioner."

It would seem that roentgenology is thought to be a nice football to kick around, and to have placed upon it the responsibility for the high cost of medical care. Why single it out for curtailment from among other so-called "mechanical tests"? Are we to believe that pathologic examinations

should also be restricted? Are bacteriologic examinations to be limited? All these and others come under the so-called "mechanical tests." The writer of the article referred to would have us infer that it took the depression to show us how many roentgen examinations have been made unnecessarily and that, perhaps, with their curtailment, the general practitioner might expect to reap financial benefits. But internists and surgeons are none too ready to undertake major procedures without the guidance of the preliminary x-ray examinations upon which they have learned to depend. Nor is it altogether certain that this form of economy will appeal to intelligent patients, and it is rather a pity to deprive the ignorant ones of the advantages of modern medical procedures.

From the article it would appear that the author has in mind to diminish the already insufficient amount of laboratory teaching, for he says: "The laboratory has been over-emphasized, and the medical student, instead of arriving at a fairly accurate diagnosis through history-taking and physical examination, has resorted to many early and oft-repeated laboratory tests or mechanical procedures." To restrict or abolish the teaching of these so-called mechanical tests would be the cause for the progress of medicine to come to a standstill, and our medical students would have to learn the stunts of the doctor of long ago, when the practice of medicine was very much the practice of diplomacy. If medical students are to be restricted in or deprived of the knowledge of the uses of such indispensable diagnostic measures as pathologic and bacteriologic examinations and roentgen-ray examinations, we might as well begin to teach them the stunts of the good old doctors of the good old days. Those were the days, we are told, of prosperity, and also the days when the good old doctor would look at your tongue, feel your pulse, ask about the folks, and how they were going to vote in the coming elections, also how the mustard seed was coming on

which was planted in the last quarter of the moon. He would then slap you kindly on the back, and tell you that your ailment was liver trouble (when it might have been pulmonary tuberculosis). After writing four or five prescriptions, among which was one for some patented Liver Regulator, he would ask you for a dollar, the price of his examination. We will admit that one dollar for a medical examination is within the reach of nearly every one, but who would prefer such an examination?

Would we be satisfied to do away with diagnostic agencies at this time and resort to the old-time custom of exploratory operations? This often proves a lucrative practice, subjecting the patient to hospital and operative expenses. If this is economy, it can only be depraved economy.

We all agree that in times such as these, members of the medical profession should consider the economic conditions of their patients. Certainly the radiologists have done their part. They have made their prices conform to the patients' ability to pay, and, besides, they have had to meet the competition with certain physicians who send their patients to be x-rayed by charity institutions while they themselves continue treating them as private patients.

Inasmuch as roentgen-ray examinations have been thought to play an important part in the high cost of medical care, would it not be interesting if organized medicine could obtain statistics on the cost and charges for all types of medical examinations and operations of all specialties of medicine? There can be no question as to what such statistics would show. In the instance of roentgenology, the costly apparatus and operating expenses raise the overhead tremendously, while the roentgenologist's charges, when compared to his costs, are moderate.

In the instance of the various surgical specialties, it would be found that the cost is small and the charge high. It has been

known to happen that x-ray examination renders an exploratory operation unnecessary, in which case the patient can well afford to pay \$25 or \$50 to save several hundred, to say nothing of his anxiety and suffering.

This is no time for suggestions regarding changes in practices which have been found indispensable in medical care. What we need is co-operation between all who practise medicine and minister to the sick, setting aside all "small petty differences and jealousy." Let it be a give-and-take proposition.

Is it not generally admitted by the unprejudiced that modern methods of precision as embodied in laboratory and radiation methods have proved of value? If any have unnecessarily subjected their patients to tests, because such were available and, in the abstract, desirable, let them exercise moderation. But surgeons and clinicians and dentists are the last individuals who ought to advise patients to do away with essential tests. To do so is to lose the ground which modern medicine has already gained.

ANNOUNCEMENTS

RADIOLOGY HONORED

When radiology received its first honor it was considered as news; now that it has been honored so many times, particularly by the American Medical Association, the National Board of Medical Examiners and others, it may be no longer considered news by some. However, we are certain that our readers will agree with us that radiology has been honored once more when one of its members has been appointed to represent radiology in America. We have just received news from Washington that Edwin C. Ernst, M.D., past president of the Radiological Society of North America, past president of the American Radium Society, to speak of only two posts of honor he has

held, has been appointed as a Permanent Trustee of the National Health Foundation, of Washington, D. C.

The National Health Foundation has made a wise selection in Dr. Ernst. They will find in him an energetic and dependable, and most capable, worker.

AMERICAN REGISTRY OF RADIOLOGICAL TECHNICIANS

H. B. Podlasky, M.D., Chairman of the American Registry of Radiological Technicians, desires to notify the radiologists of North America that the Registry is now in a position to begin the classification of approved x-ray departments for instruction in x-ray technic.

Radiologists who desire to have their courses approved are requested to send a letter of inquiry to E. A. Pohle, M.D., Ph.D., Department of Radiology, University of Wisconsin, Madison, Wisconsin.

INDIANA ROENTGEN SOCIETY

The sixth annual meeting of the Indiana Roentgen Society was held in Indianapolis on February 22. E. R. Witwer, M.D., of Detroit, addressed the Society.

The following officers were elected: *President-elect*, W. R. Cleveland, M.D., of Evansville; *Vice-president*, H. H. Inlow, M.D., of Shelbyville; *Secretary-Treasurer*, James N. Collins, M.D., of Indianapolis.

FOURTH CONGRESS, PAN-AMERICAN MEDICAL ASSOCIATION

DALLAS, TEXAS, MARCH 21-25, 1933

The Congress which has just closed is the fourth in the series this Association has successfully conducted, the first in Havana, the second in Panama, and the third in Mexico City.

In the Section on Radiology the speakers

were Albert Soiland, M.D. (Radiologic Concept of Treatment of Cancer of Breast); W. W. Watkins, M.D. (Treatment of Lung Cavities); David Escalante, M.D. (Electrotherapy in Tuberculosis); Pedro L. Farinas, M.D., and M. Mitrani, M.D. (paper in Spanish language), and Victor Randolph, M.D. (X-ray Demonstrations of Cavity Closure by Surgical Methods). Each paper was followed by discussion.

The attendance was considered excellent, and there is no question but that those who came to the Congress and participated found it well worth while.

PRELIMINARY PROGRAM OF THE AMERICAN CONGRESS OF RADIOLOGY¹

SEPTEMBER 25 TO 30, 1933, INCLUSIVE

Monday, 9:00 A.M., September 25, 1933

Address of Welcome by President of the Chicago Medical Society, Austin A. Hayden, M.D.

Address by the President of the Exposition, "A Century of Progress," President Rufus C. Dawes

Address by the Surgeon-General of Public Health of U. S., Surgeon-General Hugh S. Cumming

Address by the Editor of the *Journal of the American Medical Association*, Morris Fishbein, M.D.

Intermission—15 Minutes

Address by the President of the American Congress of Radiology, Henry K. Pancoast, M.D.

Address by Franklin H. Martin, M.D., Executive Director of American College of Surgeons

Address, "Radiosensitivity of Tumor Tissue," James Ewing, M.D.

Brief report of committees—special announcements

(Note.—Following the opening meeting, the special committee meetings of the various component radiological societies will be announced by the officers of the societies, and may take place some time after adjournment each day.)

2:00 P.M.—Adjournment

Tuesday, 9:00 A.M., September 26, 1933

Section "A," General Group of Papers

Devoted to Chest Diseases

H. KENNON DUNHAM, M.D., Cincinnati, Ohio

"The Roentgen Ray in the Study of Pathology of Pulmonary Tuberculosis."

LAWRASON BROWN, M.D., and MR. HOMER L. SAMPSON, Saranac Lake, N. Y.

"Correlation of Clinical and Roentgenological Observation in Pulmonary Tuberculosis."

F. MAURICE MCPHEDRAN, M.D., Philadelphia, Pa.

"Tuberculosis in Children."

FRED JENNER HODGES, M.D., and C. B. PEIRCE, M.D., Ann Arbor, Mich.

"The Roentgen Examination of the Heart; A Critical Study of the Frontal Silhouette."

WILLIS F. MANGES, M.D., Philadelphia, Pa.

"An Analysis of a Group of Primary Carcinomas of the Lungs, Treated with Deep X-ray Therapy."

WILLIAM H. STEWART, M.D., and H. EARL ILLICK, M.D. (by invitation)

"Where is the Diaphragm?"

11:00 A.M.—Recess

GEORGE W. HOLMES, M.D., Boston, Mass.

"Lymphoblastoma of the Chest and Elsewhere."

CHARLES A. WATERS, M.D., Baltimore, Md.

"Roentgen Diagnosis of Interlobar Pleurisy" (lantern slides)

W. WALTER WASSON, M.D., Denver, Colo.

"Accessory Sinus Diseases in Relation to Chest Diseases."

W. WARNER WATKINS, M.D., Phoenix, Ariz.

"Non-tuberculous Inflammation of the Lungs."

¹This program is almost complete. It replaces the scientific programs of the American Radium Society, the American Roentgen Ray Society, the Radiological Society of North America, also the Annual Meeting of the American College of Radiology.

WILLIAM A. EVANS, M.D., Detroit, Mich.
 "Surgical Conditions within the Chest,
 under Roentgen Observations."

LEROY SANTE, M.D., St. Louis, Mo.
 "The Radiological Detection of Obscure
 Foci of Suppuration in the Chest."

MR. REX WILSEY, Physics Dept., Research
 Lab., Eastman Kodak Co., Rochester,
 N. Y.

"Scattered X-rays in Chest Roentgen-
 ography."

2:00 P.M.—Adjournment

Wednesday, 9:00 A.M., September 27, 1933

Section "A," Gastro-intestinal Diseases

B. R. KIRKLIN, M.D., Rochester, Minn.
 "Duodenitis and its Roentgenologic
 Characteristics."

LEWIS GREGORY COLE, M.D., New York
 City

"Application of Roentgenological Find-
 ings to the Solution of Gastro-intestinal
 Problems."

JAMES T. CASE, M.D., Chicago, Ill.
 "Functional Disturbances of the Colon in
 Relation to the Roentgen Diagnosis of
 Organic Colonic Disease."

EUGENE P. PENDERGRASS, M.D., and W.
 OSLER ABBOTT, M.D., Philadelphia, Pa.
 "An Evaluation of a New Procedure in
 the Study of the Small Intestine."

JOHN L. KANTOR, M.D., and SAMUEL
 SCHECHTER, M.D., New York City
 "Colon Studies. VII.—Variations in the
 Fixation of the Cecocolon: Their Clini-
 cal Significance."

R. R. NEWELL, M.D., San Francisco, Calif.
 "Statistical Work on Visualization of the
 Gall Bladder by the Oral Method."

SHERWOOD MOORE, M.D., and EVARTS A.
 GRAHAM, M.D., St. Louis, Mo.
 "Explanation of the Errors in Diagnosis
 of Gall-bladder Disease."

11:00 A.M.—Recess

HOLLIS E. POTTER, M.D., Chicago, Ill.
 "Roentgenology of Duodenal Ulcer: (a)
 Behavior of the Stomach and Duodenum;

(b) Methods of Obtaining Outline De-
 formity in Roentgenograms."

J. J. VALLERINO, M.D., Panama, R. P.
 "Roentgenologic Studies of Amœbic
 Colitis."

NELSON M. PERCY, M.D., and DAVID S.
 BEILIN, M.D., Chicago, Ill.

"Analysis of 1,000 Consecutive Exami-
 nations of the Stomach and Duodenum
 from the Clinical, Roentgenological, and
 Surgical Viewpoints, with Particular Ref-
 erence to the Incidence, Diagnosis, and
 Treatment of Ulcer and Carcinoma of the
 Stomach."

E. T. LEDDY, M.D., Rochester, Minn.
 "Dangers of Fluoroscopy and Methods of
 Protection."

2:00 P.M.—Adjournment

Thursday, 9:00 A.M., September 28, 1933

*Section "A," Diseases of Bones and Joints;
 Bone Tumors*

CHARLES F. GESCHICKTER, M.D., Balti-
 more, Md.

"Seventy Cases of Five-year Cures in
 Sarcoma of Bone" (lantern slides).

HOWARD P. DOUB, M.D., Detroit, Mich.
 "Injuries of the Spine, Both Acute and
 Chronic."

LAWRENCE REYNOLDS, M.D., and E. R.
 WITWER, M.D., Detroit, Mich.
 "Parathyroid Disease."

WILLIAM B. COLEY, M.D., and BRADLEY
 L. COLEY, M.D., New York City
 "The Treatment of Giant-cell Tumors of
 Long Bones."

11:00 A.M.—Recess

RALPH S. BROMER, M.D., E. P. CORSON-
 WHITE, M.D., and IRVING STINE, M.D.,
 Philadelphia, Pa.

"Osteomalacic Diseases in Monkeys: A
 Metabolic and Roentgenographic Study."

D. B. PHEMISTER, M.D., Chicago, Ill.
 "X-ray Evidences of Necrosis of the
 Head of the Femur Following Intra-
 capsular Fractures of the Neck."

RAY A. CARTER, M.D., Los Angeles, Calif.

"Infectious Granulomas of the Bones and Joints, with Special Reference to Coccioid Disease."

E. C. VOGT, M.D., and C. F. MCKHANN, M.D., Boston, Mass.

"Lead Poisoning in Infants and Children."

L. G. MCCUTCHEN, M.D., St. Louis, Mo.
Moving Picture—"Reduction of Fractures and Removal of Foreign Bodies under Fluoroscopic Control, Using Oil-immersed Units and Special Fracture Device."

L. A. MILKMAN, M.D., Scranton, Pa.
"Further Observations on Spontaneous Multiple Symmetrical Fractures."

2:00 P.M.—Adjournment

Friday, 9:00 A.M., September 29, 1933
Section "A," Urology and Gynecology

LEOPOLD JACHES, M.D., and MOSES SWICK, M.D., New York City

"Studies with Opaque Media in Urology."

DON CARLOS HEUSER, M.D., Buenos Aires, Argentina

"Opaque Studies of the Uterus and Pelvis."

HANS A. JARRE, M.D., Detroit, Mich.

"Renal Peristalsis during Pyelonephritis: A Roentgen-physiologic Study."

BERNARD H. NICHOLS, M.D., Cleveland, Ohio

"Further Observations in the Diagnosis of Tumors of the Kidney."

11:00 A.M.—Recess

ERNST A. POHLE, M.D., Ph.D., Madison, Wis.

"The Fate of Thorium Dioxide in the Body after Intravenous Injection."

LEON SOLIS-COHEN, M.D., and SAMUEL BRUCK, M.D., Philadelphia, Pa.

"Roentgen Examination of the Chests of 500 Newborn with Reference to Pathology Present Other Than Enlarged Thymus."

2:00 P.M.—Adjournment

Saturday, 9:00 A.M., September 30, 1933
Section "A," Neurology and Miscellaneous

MERRILL C. SOSMAN, M.D., Boston, Mass.

"Pituitary Tumors; Radiological Aspects of Diagnosis and Treatment."

KARL KORNBUM, M.D., and FRANCIS C. GRANT, M.D., Philadelphia, Pa.

"Encephalography."

JOHN D. CAMP, M.D., Rochester, Minn.

"Spinal Cord Lesions and Their Recognition by Roentgenologic Methods."

A. HOWARD PIRIE, M.D., Montreal, Quebec, Can.

"Visualization of the Cerebro-spinal Fluid System by Air or Oxygen."

EDWIN C. ERNST, M.D., St. Louis, Mo.

"Roentgenological Considerations of Sinus Diagnosis with and without Radiopaque Oils."

11:00 A.M.—Recess

AMÉDÉE GRANGER, M.D., New Orleans, La.

"The Diagnosis of Accessory Sinuses."

FREDERICK M. LAW, M.D., New York City

"Diagnosis of Mastoid Disease."

2:00 P.M.—Adjournment

A. W. CRANE, M.D., Kalamazoo, Mich.

"The Genealogy of the X-ray."

SEELEY G. MUDD, M.D., Pasadena, Calif.

Title to be announced.

DR. W. D. COOLIDGE and DR. E. E. CHARLTON, Schenectady, N. Y.

"Some Practical Applications of the Recent Advances in Physics."

DR. CHARLES C. LAURITSEN, Pasadena, Calif.

"The Solution of Some Problems in High Voltage Equipment."

DR. LAURISTON S. TAYLOR, Washington, D. C.

"Application of Physical Measurements in Clinical Irradiation."

G. FAILLA, D.Sc., New York City

"Physical and Biological Characteristics of 700 K.V. X-ray."

E. H. QUIMBY, M.A., and M. M. COPELAND, M.D., New York City
 "Distribution of X-rays within the Human Body."

G. FAILLA, D.Sc., and L. MARINELLI, B.Sc., New York City
 "The Measurement of Gamma Rays in Roentgens."

FLOYD F. CRAVER, M.D., and WILLIAM S. MACCOMB, M.D., New York City
 "Heublein's Method of Continuous Irradiation of the Entire Body in the Treatment of Generalized Neoplasms."

T. LEUCUTIA, M.D., Detroit, Mich.
 "The Problems of Protection and Their Solution in Short Wave Therapy."

PAUL C. HODGES, M.D., Chicago, Ill.
 "The Place of Roentgenology in the University: A Program of Teaching and Investigation."

A. MUTSCHELLER, Ph.D., Westinghouse X-ray Corp., Long Island City, N. Y.
 "Studies on Composite X-ray Filters."

Wednesday, 9:00 A.M., September 27, 1933
Section "B," Breast Diseases

IRA H. LOCKWOOD, M.D., Kansas City, Mo.
 "Further Observations in Roentgen Diagnosis of the Breast."

ALBERT SOILAND, M.D., Los Angeles, Calif.
 "Combined Surface and Interstitial Radiation in the Treatment of Mammary Cancer."

BURTON J. LEE, M.D., New York City
 "Irradiation Results in the Treatment of Cancer of the Breast."

ERNST A. MAY, M.D., Newark, N. J.
 "Distribution of X-ray Intensity in Tissue with the Central Ray Striking the Surface, at Angles other than 90 Degrees."

11:00 A.M.—Recess

GEORGE E. PFAHLER, M.D., and JACOB H. VASTINE, M.D., Philadelphia, Pa.
 "Technic and Results of Irradiation in Carcinoma of the Breast."

GORDON E. RICHARDS, M.D., Toronto, Ont., Canada

"The Treatment of Chest Wall Secondaries in Breast Carcinoma: A Preliminary Report of a New Technic."

A. U. DESJARDINS, M.D., Rochester, Minn.
 "A Classification of Tumors from the Standpoint of Radiosensitiveness."

ALEXANDER BRUNSCHWIG, M.D., Chicago, Ill.

"Histopathology of Irradiated Hodgkin's Disease and Lymphoblastoma."

2:00 P.M.—Adjournment

Thursday, 9:00 A.M., September 28, 1933
Section "B," Cancer of the Mouth, Skin; Miscellaneous

CHARLES L. MARTIN, M.D., Dallas, Texas
 "Irradiation Treatment of Cancer of the Lip and Mouth; Technic and Results"

DOUGLAS QUICK, M.D., New York City
 "Management of Cancer of the Mouth and the Cervical Lymphatics."

HAYES E. MARTIN, M.D., and ROBERT E. McNATTIN, M.D., New York City

"The Treatment of Carcinoma of the Pharynx, Tonsil, and Extrinsic Larynx by Divided Doses of Roentgen Therapy."

GEORGE W. GRIER, M.D., Pittsburgh, Pa.
 "Cancer of the Skin."

JOSEPH JORDAN ELLER, M.D., New York City

"Results of Irradiation in Diseases of the Skin."

MAURICE LENZ, M.D., CORNELIUS COAKLEY, M.D., and A. P. STOUT, M.D., New York City

"Roentgentherapy of Epitheliomas of the Pharynx and Larynx."

11:00 A.M.—Recess

LEO E. PARISEAU, M.D., Montreal, Quebec, Can.

"The General and Medical History of Electricity Told with Old Books Taken from my Library."

J. ERNEST GENDREAU, M.D., Montreal, Quebec, Can.

"Three Years of 300 K.V. Cancer Therapy."

IRA I. KAPLAN, M.D., MILTON FRIEDMAN, M.D., RIEVA ROSH, M.D., and CARL B. BRAESTRUP, B.S.C., P.E., New York City
"Protracted Irradiation in the Treatment of Neoplasms of the Mouth and Pharynx: A Comparison between X-rays (Coutard Technic), 5-gram Radium Pack, and Small Radium Pack."

BERNARD P. WIDMANN, M.D., Philadelphia
"The Roentgen-ray and Radium Treatment of Cancer of the Lip."

FRANK E. SIMPSON, M.D., Chicago, Ill.
"Radium Treatment."

2:00 P.M.—Adjournment

Friday, 9:00 A.M., September 29, 1933
Section "B," Urology and Gynecology, and Abdominal Disease

BENJAMIN S. BARRINGER, M.D., New York City
"The Irradiation Treatment of Carcinoma of the Bladder."

WILLIAM P. HEALY, M.D., New York City
"Radiation Treatment of Carcinoma of the Cervix."

HENRY L. SCHMITZ, M.D., Chicago, Ill.
"Irradiation Treatment of Carcinoma of the Uterus."

LEDA J. STACY, M.D., Rochester, Minn.
"Benign Diseases of the Uterus."

RUSSELL H. FERGUSON, M.D., New York City
"Studies in the Diagnosis and Treatment of Teratoma Testis."

11:00 A.M.—Recess

F. LIBERSON, M.D., Stapleton, N. Y.
"The Multi-perforated Lead Screen in Deep Therapy."

H. H. BOWING, M.D., Rochester, Minn.
"Radium Treatment of Primary Carcinoma of the Rectum."

EDWARD L. JENKINSON, M.D., and A. R.

ELLIOTT, M.D., Chicago, Ill.

"Abdominal Hodgkin's Disease."

EDWARD H. SKINNER, M.D., Kansas City, Mo.

"Radiology and the Radiologist."

FRANK E. SIMPSON, M.D., Chicago, Ill.

"Technic of Treatment of Cancer of Cervix with Radon."

2:00 P.M.—Adjournment

Saturday, 9:00 A.M., September 30, 1933
Section "B," Miscellaneous

LEON J. MENVILLE, M.D., New Orleans.
"Visualized Lymphatics."

WILLIAM EDWARD CHAMBERLAIN, M.D., Philadelphia, Pa.

"Pernicious Leukopenia."

EDWIN A. MERRITT, M.D., and EDGAR M. McPEAK, M.D., Washington, D. C.

"Diagnosis and Treatment of Parathyroid Dysfunction."

ROLAND E. LOUCKS, M.D., Detroit, Mich.

"Radium in the Treatment of Hyperthyroidism."

THOMAS A. GROOVER, M.D., and A. C. CHRISTIE, M.D., Washington, D. C.

"X-ray Treatment of Hyperthyroidism."

11:00 A.M.—Recess

U. V. PORTMANN, M.D., Cleveland, Ohio

"The Malignant Diseases of the Thyroid Gland."

JOHN M. KEICHLIN, M.D., Huntingdon, Pa.

"A Report of 62 Cases of Herpes Zoster Treated with X-rays."

BERNARD F. SCHREINER, M.D., Buffalo, N. Y., and WILLIAM H. WEHR, M.D., Buffalo, N. Y.

"Primary Newgrowths Involving the Hand."

WILLIAM H. CAMERON, M.D., New York City

"Training for Radium Therapy."

PEDRO L. FARINAS, M.D., Havana, Cuba
Title to be announced later.

2:00 P.M.—Adjournment

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CONTRAST MEDIA

Iodine Poisoning and Iodism from Lipiodol. D. A. Carmichael. *Can. Med. Assn. Jour.*, March, 1932, XXVI, 319, 320.

Recently introduced solutions and compounds containing large percentages of iodine are now extensively used therapeutically or as opaque substances for radiography and are potential sources of poisoning and iodism. Unless the danger is fully recognized and suitable measures for prevention or timely treatment employed, the inevitable errors or accidents of technic, and the well known idiosyncrasy to iodine, will undoubtedly lead with increased frequency to the reappearance of iodine poisoning.

The author reports two cases of iodism and iodine poisoning following the use of lipiodol for bronchography.

The first case was that of a nurse who received 20 c.c. of lipiodol by the transglottic method. Immediate films showed extensive left-sided bronchiectasis. Six hours later she became acutely ill with vomiting, diarrhea, faintness, intense pain in the hands, wrists, and face, followed by the appearance of marked urticarial wheals over the arms, face, and neck. These coalesced and formed bullous vesicles, many of which were hemorrhagic. The contents of these vesicles quickly coagulated, forming tough crusts beneath which new epithelium slowly formed, ending in complete recovery without scar in three months.

The second case was that of a woman suffering from moderate arthritis, who received 30 c.c. lipiodol by the supraglottic method. Both lower lobe bronchi were well filled, the films also showing a thin line of oil in the gastric canal. Some hours later the patient became nauseated, weak, dyspneic, and was

troubled with vomiting and diarrhea. Marked swelling and blackness of the tongue developed, with hemorrhagic blebs on the eyelids, fingers, toes, buttocks, tip of tongue, and soft palate. Laryngeal edema also developed. Improvement was rapid and recovery was complete in four weeks.

Treatment in both cases was symptomatic, with adrenalin hypodermically and calcium lactate *per os*. The skin lesions were punctured and painted with 1 per cent picric acid solution.

Experimental and clinical evidence shows that iodine absorption from the bronchial mucous membrane is negligible. If, therefore, idiosyncrasy is excluded, absorption in these two instances must have occurred from the gastro-intestinal tract. In both cases the lipiodol was introduced under visual control, and could reach the stomach only secondarily from the trachea and bronchi. How may this occur? Partly by cough and swallowing during the instillation, but certainly in much greater quantity from suppressing cough and substituting clearing the throat and swallowing during the fluoroscopic and radiographic examinations, or failure to expectorate the oil raised by cough later. If this be true even the most exacting transglottic method of administration would not of itself be sufficient to prevent the subsequent appearance of toxic symptoms.

Additional precautions are suggested by the author. The patient should be instructed that at no time during the procedure, or afterward so long as the taste or smell of oil is recognized, should the sputum be swallowed. Careful search will reveal any oil in the stomach, and, if sufficient is found to contain even one grain of iodine, it should be removed by gastric lavage, induced vomiting, or a brisk saline cathartic. The antidote, starch, should be given as

long as the vomited or aspirated contents have a blue color. These measures on the part of the author have prevented the repetition of the experience in his practice.

L. J. CARTER, M.D.

THE ESOPHAGUS (DIAGNOSIS)

A Contribution to the Formation of Diverticula in the Lower Esophagus. Karl Nemec. *Röntgenpraxis*, April, 1932, IV, 304-309.

Diverticula in the lower portion of the esophagus are comparatively rare and usually small. Hiatus hernias may simulate large diverticula. The shape of the stomach is of great importance in differentiating the two, but greater yet is the appearance of the mucosa in the questionable sac, which shows gastric mucosa in a hernia and esophageal in a diverticulum. In diverticula one may find remnants of barium even after some days, a fact which is unlikely in diaphragmatic hernias. A case with a very large diverticulum in the lower third of the esophagus is described.

H. W. HEFKE, M.D.

DOSAGE

Ionization Measurements on the Influence of Secondary Beta Rays in Gamma-ray Therapy. E. Stahel. *Strahlentherapie*, 1932, XLIV, 575-584.

The intensity and penetrability of secondary radiation of various metal filters were studied. It appeared that the differences in intensity are insignificant and that the penetrability of secondary beta rays is small. There is, however, a characteristic difference between high atomic metals and those of medium atomic weight. For practical purposes it seems that the secondary filtration is insignificant in the case of transcutaneous treatment. In intratumoral irradiation the use of secondary filters of medium atomic weight permits of a more efficient exposure. Celluloid, aluminum, copper, gold, lead, and platinum were used in the investigation. As non-toxic metals for the secondary filters, silver, nickel, and chromium may be considered.

ERNST A. POHLE, M.D., Ph.D.

EXPERIMENTAL STUDIES

The Effect of Roentgen Rays on the Function of Secretory Organs. Observations on the Living Organ in Luminescent Light. I.—The Liver. W. Hartoch and M. Israelski. *Strahlentherapie*, 1932, XLIV, 557-574.

The authors exposed 100 frogs to roentgen rays. The technic was as follows: 180 K.V., 5 ma., 10 mm. Al or 0.5 mm. Cu, from 30 to 35 cm. F.S.D.,

dose from 10 to 4,000 r in one sitting given over the entire body or over the liver region only. The animals were paralyzed by curare. From 1.2 to 1.5 c.c. of uranin, injected subcutaneously, stained the liver and the serum a light green color. Thirty untreated frogs served as controls.

It appeared that there was no difference between the effects of the total body exposure and the exposure of the liver region alone. Some frogs lived up to 35 days after the total body exposure to high doses, while warm-blooded animals died within a few days after being exposed to only a small fraction of the dose. Comparing the irradiated and non-irradiated animals, it appeared that the excretion of the dye in the liver was definitely delayed in the first group. The methods of intravital microscopy in luminescent light were used in this investigation. The delay in excretion, following doses of 500 r and more, manifests itself five hours following exposure and lasts at least three weeks. The injury to the liver was augmented with increasing dosage. Intravital microscopy is recommended as an excellent method for the study of the function of secretory organs.

ERNST A. POHLE, M.D., Ph.D.

The Effect of Roentgen Rays on the Capacity of Rat Tumors to Absorb Iodine and Bismuth. Gösta Jansson. *Acta Radiologica*, 1932, XIII, Fasc. 5, pp. 533-550.

From experimental work the author concludes that small doses of x-rays have no effect on the ability of rat tumors to absorb iodine. If one uses somewhat larger doses of radiation, the absorbing power for iodine is reduced regardless of whether the filtration is heavy or not. This effect does not appear during the first twenty-four hours, but only after a few days.

The effect upon the absorption of bismuth by these tumors is exactly the opposite, absorption being increased as a result of irradiation.

A. L. HART, M.D.

Some Histologic Studies of the Action of Radium Alone and Combined with Freezing on the Neuroretic of the Spinal Cord of Full-grown Rabbits. Luigi Pilati. *Riv. di radiol. e fisica med.*, November, 1932, IV, 525-534.

From his study the author shows that the neuroreticulum is radioresistant. Only after strong doses was it possible to obtain minor lesions (in the form of ingrowth of neurofibrils), vacuolization of the cytoplasm, thickening of the nodal points, and, in rare instances, signs of disintegration or disorder of the neuroreticulum. By a combined action of radium and freezing there was produced a conglutination of the neuroreticulum of Donaggio in the form of scattered islets amid intact cells, an effect which has

been observed by the combined action of x-rays and freezing.

E. T. LEDDY, M.D.

The Placenta and the Reticulo-endothelial System, Especially on the Roentgenography of Placenta. Sh. Katsuya. *Jap. Jour. Obstet. and Gynecol.*, April, 1932, XV, 77-87.

The author believes that the placenta in the pregnant animal is as important an organ of the reticulo-endothelial system as the liver and spleen. Following the work of Radt and Oka, he injected thorium dioxide intravenously into pregnant guinea pigs, rabbits, and mice, made roentgenograms of the animals, and obtained visualization of the placenta.

In the guinea pig, from 2.5 to 4 c.c. of 25 per cent thorium dioxide, divided into two doses, were injected into the vein of the hind limb; in the rabbit, 11 c.c. divided into three doses were injected into the auricular vein, and 3 c.c. in one injection were administered into the tail vein of the mouse.

The author is of the opinion that it may be proved by means of radiography of the placenta that the decrease in the antitoxic function of the reticulo-endothelial system is a very important factor in the toxemia of pregnancy.

J. N. ANÉ, M.D.

The Influence of Irradiated Barley on the Composition of the Growing Bone. Ludwig Pincussen. *Strahlentherapie*, May 11, 1932, XLIV, 183-192.

Young growing rats which were chiefly fed barley showed more rapid bone development if the barley had been irradiated with ultra-violet light. The type of irradiation is of considerable importance, since barley irradiated too long had much less effect. Definite relations were also found between the weight of the animal and the bones, as well as the ratio Ca:Mg. If barley is kept in storage for a considerable period of time after irradiation, it retains the properties observed in barley fed to the rats immediately after exposure.

ERNST A. POHLE, M.D., Ph.D.

The Hypophysis and the Metabolism of Fat. Antonino Spinelli. *Archivio di Radiologia*, March-April, 1932, VIII, 290-311.

The author, of the Royal Surgical Clinic of Rome, reports some experiments he did on rabbits, the hypophysis of which was irradiated to effect fat metabolism. The technic employed was 180 K.V., 2 ma., 0.5 zinc plus 2 mm. aluminum filter, 23 cm. T.S.D., and from 1/10 to 1/2 H.E.D. was given at each exposure to temporal fields. In rabbits irradiated with repeated stimulating doses there was no difference between young and adult animals; both added weight more rapidly than the controls, but this growth was more marked in the skeleton than

in the soft parts. In the rabbits treated with a single massive dose of an inhibiting type, the results were variable. Some of the young animals after a transitory arrest in development grew like those which had had stimulating doses; others lagged behind the controls. There was much individual variation among the full-grown animals. Some did not vary greatly from the controls, while others showed marked accumulation of fat. The author concludes that irradiation of the hypophysis has a marked effect on fat metabolism. An extensive bibliography is appended to the paper.

E. T. LEDDY, M.D.

The Influence of Alpha, Beta, and Gamma Rays of Radium on the Aërobreathing of Animal Organisms. Julius Stoklasa. *Strahlentherapie*, April 13, 1932, XLIII, 685-700.

The author studied the influence of radium on the aërobreathing in different animals. He came to the conclusion that the breathing intensity, particularly of fishes and guinea pigs, is increased by alpha rays but decreased by beta plus gamma rays. The exposure to pure gamma radiation increases the intensity of breathing—however, much less than does exposure to alpha rays.

Other experiments were undertaken in order to explain the etiology of the lung carcinoma in miners in the region of Joachimsthal. It was found that the lungs of animals which were subject to radium exposure for a long period of time showed marked acidity, due to the formation of lactic acid. Other enzymes in the lung, particularly oxidase and peroxidase, were partly destroyed by irradiation. This, of course, made the further decomposition of lactic acid impossible. It also appeared that the CO₂ production as compared with normal lungs was greatly decreased.

ERNST A. POHLE, M.D., Ph.D.

The Lungs of Children with Ascaris: A Roentgenologic Study. A. E. Keller, H. T. Hillstrom, and R. S. Gass. *Jour. Am. Med. Assn.*, Oct. 8, 1932, XCIX, 1249-1251.

Pneumonia and various respiratory symptoms can be produced experimentally by the feeding of ripe pig ascaris eggs.

Workers have from time to time suggested that various pathologic conditions might arise in man as a result of the migration of ascaris larvae through the lungs. Experimentation has shown that during the stage of migration definite pulmonary involvement occurs.

Roentgen examinations were made of 80 children with ascaris and negative tuberculin tests, and a control group of 40 children without ascaris and with a negative tuberculin test. No significant differences in either diaphragmatic or pleural changes

could be demonstrated in either group. The observations suggest that in children who are infected with ascaris and show no response to tuberculin tests the widening in the hilar areas with increase in the bronchovascular markings are possibly due to the repeated migration of ascaris larvæ through the lungs. The changes seen in the roentgenogram are similar to those seen in the childhood type of hilar tuberculosis and may resemble changes following repeated non-specific infections of the lungs.

C. G. SUTHERLAND, M.D.

GASTRO-INTESTINAL TRACT (DIAGNOSIS)

Acute Intestinal Obstruction, Due to Mesenteric Defects Requiring Massive Resection. Charles Reid Edwards. *Jour. Am. Med. Assn.*, July 23, 1932, XCIX, 278-280.

Most of the acquired changes within the mesentery have their origin in inflammatory processes, and unless there is a complete interruption of the circulation, as in mesenteric vascular occlusion, surgical intervention is rarely indicated. Neoplasms involve the mesentery, but in a majority of cases a radical surgical procedure is contra-indicated. Cysts and other tumors developing in this region may require radical surgical measures; however, they are rare. Adhesions frequently demand operation for relief.

Trauma of the abdomen may rupture mesenteric vessels or separate the intestine from its mesentery, causing severe hemorrhage, or it may produce a wound in the mesentery which will allow coils of intestine to pass through, and, later, to become strangulated. Congenital defects do occur. The mesentery may be excessively long or too short; sections may be missing, or there may be anomalous developments in the arrangement of the blood supply. The translucent spaces may be actual openings in the mesentery. Therefore, a hole appears within an anastomotic loop, and it may permit a coil of intestine to pass through.

Intestinal obstruction caused by a passage of a loop of small bowel through this abnormal opening in the mesentery is probably the rarest of all factors responsible for intestinal obstruction, and the infrequency of this condition with a consideration of the extent of its pathologic manifestations prompts this essay. Just what mechanism is responsible for the passage of a loop of bowel through this aperture is a matter of conjecture. The size and shape of the aperture would almost preclude the possibility of a spontaneous reduction, once the bowel had passed through. Once a loop has been projected through this opening, distention within the loop and peristaltic movement serve to force more and more of the intestine through the opening, only to cause strangulation. Early operation is the only

hope the patient has for recovery. The percentage of recoveries has been high when reduction of the bowel could be effected.

C. G. SUTHERLAND, M.D.

Roentgenologic Diagnosis of Neoplastic Diseases of the Stomach. B. R. Kirklin and H. M. Weber. *Am. Jour. Cancer*, September, 1932, XVI, 1134-1143.

The authors review the x-ray signs of neoplastic diseases of the stomach. They stress the fact that at the Mayo Clinic during 1930 almost three-fourths of the gastric lesions following operations were malignant. In case of doubt they feel that one should lean towards the diagnosis of malignancy. They emphasize the desirability of active personal co-operation of the roentgenologist and the clinician. According to the authors, the annual health examination should always comprise a roentgenologic investigation of the alimentary tract.

JOHN R. CARTY, M.D.

Diseases of the Large Intestine. C. C. McClure. *Arch. Surg.*, March, 1932, XXIV, 411-425.

This is a general article on the common diseases and abnormalities of the colon, with comments on these conditions. The article is abundantly illustrated. The author takes up the following conditions: Spastic colitis; ulcerative colitis, pericolicitis; appendicitis; foreign bodies; tuberculosis; diverticula, and carcinomas.

HOWARD P. DOUB, M.D.

A Case of Volvulus of the Stomach. C. W. Burns and Earl Stephenson. *Can. Med. Assn. Jour.*, March, 1932, XXVI, 328-330.

Volvulus of the stomach is of rare occurrence. There is considerable discussion on the part of those reporting cases in the literature as to the proper use of the terms "volvulus" and "torsion," as applied to this rare rotation of the stomach. The authors consider their case to be one of true volvulus, *i.e.*, one of complete rotation through 180 degrees.

The patient, a well-nourished female infant, 4 months old, was admitted to the St. Boniface Hospital, with a history of vomiting and constipation for twenty-four hours. The baby was very ill, the entire epigastrium being occupied by a mass which could be palpated and visualized. Below this tumor mass the abdomen was flat and rigid.

The pre-operative diagnosis was acute intussusception extending into the transverse colon. Operation under ether anesthesia revealed a distended stomach, bluish-black in color, owing to strangulation of its blood supply. The pylorus was in the left hypochondrium. By rotating the pyloric end clock-wise, the stomach regained its normal position, there being no adhesions. When thus released, fluid

regurgitated into the mouth, and the tumor was reduced in size. The circulation quickly returned. In the absence of distention, the abdomen was easily and quickly closed. The child's general condition was good. Within the hour a feeding of dextro-maltose was taken. Half an hour later the child vomited and expired in a convulsive seizure.

At postmortem the head was negative, and the thymus weighed 28 grams (normal: from 1 to 12 grams). There were a few small petechial hemorrhages in the pleura and pericardium; the rest of the thoracic contents was normal. The left side of the diaphragm had an opening one and a half inches in diameter, leading into a hernial sac which contained the relatively large spleen. The stomach was of dark red color; the wall definitely thickened; the mesenteric glands were enlarged. The authors conclude that the death was a thymic one.

L. J. CARTER, M.D.

Diverticulosis of the Colon and Sigmoid Carcinoma. H. Strauss. *Med. Klinik*, April 1, 1932, XXVIII, 473-475.

The occurrence of carcinoma of the sigmoid in cases of diverticulosis of the colon is given as 30 per cent in the Mayo Clinic. From other sources it is reported as rare. The author considers the coincidence of the two diseases as unusual. Only once could he demonstrate both lesions in one patient. The case is described and roentgenograms are shown. Three times he has seen "pseudo-carcinomas," that is, an infiltrative sigmoiditis with an inflammatory tumor. In some of these cases only a biopsy can clear the diagnosis. Clinically and roentgenologically, a definite statement as to the benign or malignant character cannot always be made. The roentgenologic appearance of diverticulosis has been described by many authors in detail, and it is known that diverticula may be found in a large percentage of persons over 45 years of age. By an infection of the diverticula, a diverticulitis develops which may occasionally lead to phlegmonous processes and abscesses. These may present all the clinical and roentgenologic features of a carcinoma.

H. W. HEFKE, M.D.

Chronic Ulcerative Colitis Associated with Peptic Ulcer. J. Arnold Bagen and Andrew B. Rivers. *Med. Clin. N. A.*, May, 1932, XV, 1419-1429.

The authors studied the association of peptic ulcer and chronic ulcerative colitis in 500 cases of the latter condition. While it was expected that these conditions would be found to coexist frequently, definite evidence of an associated peptic ulcer was found in only 16 cases of chronic ulcerative colitis. Twelve of the 13 ulcers which were disclosed roentgenologically were duodenal, and one was gastric.

In eight cases the patient's original complaint was indicative of ulcer and in five cases symptoms of ulcerative colitis preceded those of peptic ulcer. It was noted in this series that treatment, if successful in relieving the symptoms of colitis, also resulted in quiescence of the syndrome of peptic ulcer. As a rule, no definitely characteristic syndrome of uncomplicated ulcer was obtained, except in five cases.

The authors are of the opinion that in this series of cases there was some evidence of allied etiology of chronic ulcerative colitis and peptic ulcer. However, the rarity of association of the two conditions is noteworthy. It is believed, however, that the possibility of the association should be remembered and that all patients with chronic ulcerative colitis and gastric symptoms should have a thorough examination of the stomach and duodenum.

J. N. ANÉ, M.D.

The Diagnostic Significance of Hematemesis. Andrew B. Rivers and Dwight L. Wilbur. *Jour. Am. Med. Assn.*, May 7, 1932, XCVIII, 1629-1631.

Hemorrhages of the gastro-intestinal tract are often dramatic and alarming, but the primary hemorrhage is rarely fatal. It is sometimes impossible to discover the source of the bleeding, even at operation or necropsy. Hasty surgical treatment is frequently ineffective in controlling bleeding. In 668 cases studied, 90 per cent were found to have some intrinsic lesion of the stomach, duodenum, or jejunum; more than 75 per cent were caused by duodenal, anastomotic, or benign gastric ulcer. Duodenal ulcer, carcinoma, and gastric ulcer were responsible for 50, 13 and 6.4 per cent, respectively. Cirrhosis and splenic anemia and that from all other causes totaled only 9.6 per cent. Diseases in which varices are likely to develop accounted for 5.5 per cent of cases in these series.

C. G. SUTHERLAND, M.D.

GALL BLADDER (NORMAL AND PATHOLOGIC)

The Cholesterol Function of the Gall Bladder. Editorial. *Jour. Am. Med. Assn.*, Sept. 24, 1932, XCIX, 1086.

The concentrating activity as demonstrated by Rous and McMaster, in 1921, served to renew interest in the gall bladder and initiated a series of investigations which have been fruitful. This organ has an important motor function in the discharge of bile into the duodenum. Besides water and other substances it absorbs calcium and bile salts. It secretes mucus and makes bile more acid. It is now generally accepted that the gall-bladder mucosa absorbs from the bile cholesterol which is present in its lumen. It is agreed that in the presence of inflammation the lipid is excreted by the gall-bladder wall. The demonstration of excretion by the gall

bladder has led to a convincing explanation of the pathogenesis of the well-known "strawberry gall bladder." The accumulation of cholesterol under the mucosa is due to the fact that further excretion has become impossible, because the bile is so saturated that it can no longer take up any more of the lipid. This idea is substantiated by the observation that such bile contains a tremendously high concentration of cholesterol and often exhibits shimmering crystals of it in suspension. The rôle of bile salts in promoting the solution of cholesterol is a factor of great importance. Unlike cholesterol, the inflamed gall bladder absorbs bile salts and thus leads to conditions which render the bile even less able to take up the lipid and, in fact, cause precipitation of it in the form of crystals or about other centers where it is converted into actual stones over the course of time.

C. G. SUTHERLAND, M.D.

GENITO-URINARY TRACT (DIAGNOSIS)

Renal Anomalies: Case Reports. J. A. H. Magoun. *Jour. Urol.*, April, 1932, XXVII, 435-463.

The author divides his cases of renal anomalies into eight groups, as follows:

1. Cases with unilateral reduplication of the renal pelvis and ureter, without clinical evidence of pathology either within or out of the kidney.
2. Cases with unilateral reduplication of the renal pelvis, with partial or complete reduplication of the ureter, accompanied by extrarenal pathology.
3. Same as Groups 1 and 2, with pathology of the urinary system.
4. Cases with bilateral complete reduplication of the pelvis and ureter.
5. Cases with horseshoe kidney.
6. Cases with ectopic kidney.
7. Cases with hypoplastic kidney.
8. Cases with faulty rotation of the kidney.

This paper presents several points of interest worthy of discussion and consideration.

The question arises as to whether or not uncomplicated reduplication of the ureter and pelvis can produce symptoms. All the patients in this series complained of pain on the side in which the deformity existed. It would seem possible that an anomalous nerve supply may be present and produce a nephralgia similar to that for which Papin divides the renal nerves.

The majority of the cases were complicated by some pathologic condition within or without the urinary tract.

It has been observed that occasionally following plastic operations on the renal pelvis the anatomic condition is unimproved in spite of a symptomatic cure. A post-operative pyelonephritis occurring in a kidney previously free from infection may cause a dilatation of the pelvis and explain this paradox.

Ectopic kidney due to the deformities of its blood vessels and its connective tissue surroundings is frequently subject to disease. Radical surgery would seem best in its treatment.

The employment of various tests of differential renal function is advocated. A pyelogram showing a large hydronephrosis does not necessarily mean that the hydronephrotic kidney does not support life. The possibility of an opposite hypoplastic kidney should always be considered.

Many interesting roentgenograms illustrative of the conditions described accompany the article.

DAVIS H. PARDOLL, M.D.

Intravenous Urography: A New Diagnostic Procedure for the General Practitioner. Miley B. Wesson. *Urol. and Cutan. Rev.*, May, 1932, XXXVI, 296-307.

In 1923, Rowntree and his associates in the Mayo Clinic obtained faint outlines of the renal pelves and bladder after the intravenous injection of 200 c.c. or more of 15 per cent sodium iodide solution.

Uroselectan or iopax was prepared in 1929, by Binz, von Lichtenberg, and Swick. Shortly thereafter Bronner, of Cologne, gave skiodan to the medical profession. Von Lichtenberg later reported favorable results with neo-iopax (Uroselectan B), which contains only three-fifths as much iodine as does iopax or skiodan.

As a rule, roentgenograms made using the intravenous method are generally less clear and do not always delineate the minor degrees of deformities in the calices, because there is a 5 per cent concentration as against a 12 per cent or 15 per cent in the retrograde method. The elimination of the contrast substance is an index of kidney activity; therefore, in cases in which the affected kidney is not functioning, intravenous pyelography will prove of no value in outlining the pelvis.

Neo-iopax and skiodan are dispensed in sterile solution ready for use, whereas the iopax powder has to be diluted and autoclaved. The author is of the opinion that a child of 7 years is able to tolerate a full dose of neo-iopax, and one of six weeks, a quarter dose. The gravity method of administration is considered safe and is preferred by the author to the syringe method. Fifteen minutes should be allowed for the injection of the 100 c.c. of solution of iopax, while skiodan, employed in an average dose of 50 c.c., and neo-iopax, of which only 20 c.c. are used, can be given much faster. When skiodan is used, roentgenograms should be made at 15- and 45-minute intervals, the bladder being emptied before the second film. In the case of uroselectan the greatest concentration is often found at one and a quarter hours, a third film becoming necessary. When using neo-iopax roentgenograms should be made at 5, 15, and 30 minutes after injection.

Intravenous pyelography is dangerous when em-

ployed in patients with advanced renal insufficiency and general weakness. Particularly prone to reactions are cases of idiosyncrasy to iodine, hyperthyreosis, pregnancy, and active tuberculosis, thyrotoxicosis, acute and chronic renal diseases. In cases of renal tumors, polycystic kidneys, and purulent infection, because of failure in the excretion of the substance, the roentgenograms may prove misleading. For this reason it has proved a disappointment in infants with pyuria.

Intravenous pyelography is indicated when cystoscopy is impossible, as in infants, or difficult, as in cases of contracted bladder, hypertrophy of the prostate, urethral stricture, extensive vesical neoplasms, stenosis of the ureter. It should be used as a routine in the case of suspected ureteral stone. If the drug is eliminated equally well by both kidneys, there is no stone. Double kidneys showing three pelves are commonly found by retrograde pyelography, but the fourth pelvis does not show without the intravenous medium because of the peculiar ending of the ureter. In cases in which both methods of pyelography are used it is important that the intravenous roentgenograms be made first, as the presence of a catheter in the pelvis may interrupt the excretion of the substance by that kidney.

While intravenous pyelography is considered a valuable adjunct in diagnosis, it should be remembered that the value of the method depends upon the accuracy of interpretation and the competency and experience of the roentgenologist. In the author's opinion intravenous urography will never eliminate cystoscopic examination, for valuable additional information can be obtained in most cases by the use of this procedure.

J. N. ANÉ, M.D.

GYNECOLOGY AND OBSTETRICS

A New Case of Protrusion of the Acetabulum of Obstetrical Importance. (Contribution to Obstetrical Measurement of the Pelvis.) Ludwig Sinn. *Röntgenpraxis*, October, 1932, IV, 856-865.

Protrusion of the acetabulum, not a disease in itself but the result of several different etiologic factors, is not so rare as one used to think. It might be of great importance in obstetrics. The roentgenographic methods of pelvic mensuration are numerous, which seems to indicate that none is entirely satisfactory. The simplest and yet most accurate appears to be Thoms' method, the details of which should be read in the original. The literature contains a description of a case. Obstetrical difficulties depend on the amount of protrusion into the pelvic lumen, which can be determined by roentgenologic means.

H. W. HEFKE, M.D.

Myosarcoma of the Uterus, with Lung Metastases. Karl Herman. *Röntgenpraxis*, March 1, 1932, IV, 211-213.

Uterine myomas with malignant (sarcomatous) degeneration are not frequent. Such a case is described in detail. Locally, the tumor appeared benign, but anemia, fever, loss of weight, and cachexia indicated malignancy. The tumor was removed surgically and found to contain areas of malignant degeneration. About five months afterwards the patient's condition grew worse and metastases could be demonstrated in the right hilus and lung.

H. W. HEFKE, M.D.

HEART AND VASCULAR SYSTEM (DIAGNOSIS)

Suppurative Pericarditis: Report of a Case. Edwin M. Miller. *Jour. Am. Med. Assn.*, March 12, 1932, XCVIII, 873-875.

Suppuration within the pericardium is never primary. It may follow a penetrating wound; it may appear as a metastatic abscess secondary to a general infection of the blood stream; it may develop by direct lymphatic extension from a suppurative focus within the mediastinum, lung tissue, or pleural space. Clinically, it is seen most commonly after pneumonia, and the pneumococcus is the prevailing organism.

The author reports one case which clinically was considered diffuse bronchopneumonia. A roentgenogram revealed a large, rounded cardiac shadow with relatively clear lung fields, which led at once to the suspicion of pericarditis with effusion. Aspiration revealed the presence within the pericardium of pus containing the pneumococcus. Surgical drainage was instituted, followed by recovery of the patient.

C. G. SUTHERLAND, M.D.

Influence of the Weather on Man, Demonstrated by the Relations between the Physiologic Fluctuations of the Blood Pressure and Air Mass Changes. Kurt Franke. *Strahlentherapie*, March 9, 1932, XLIII, 517-546.

The author studied the daily fluctuations of the blood pressure in persons with increased and normal pressure, and in about 90 per cent, he found the variations to be of similar nature in both groups. During the period from 1924 to 1927, he found approximately six times a month definite variations in blood pressure lasting from one to three days. Fluctuations did not start on the same day in all persons. It was difficult to establish definite relations between the blood pressure changes and the various components of the weather. However, in about 80 per cent of air mass changes, there was a definite fluctuation in the blood pressure. Air masses com-

ing from the polar region and Eastern continent produced an increase, and those coming from the warmer Atlantic region and subtropical areas caused a decrease in the blood pressure. It is possible that the change in the air ionization may be responsible for the observed blood pressure fluctuations, particularly in view of the investigations of Dessauer with unipolar charged air.

ERNST A. POHLE, M.D., Ph.D.

HEART AND VASCULAR SYSTEM (THERAPY)

The Therapeutic Application of the Roentgen Ray in Angina Pectoris. E. C. Samuel and E. R. Bowie. *Am. Jour. Roentgenol. and Rad. Ther.*, June, 1932, XXVII, 870-876.

Nineteen patients have been given small series of x-ray treatments supplementary to other more widely accepted therapeutic measures for angina pectoris. All were individuals past middle life, fifteen being male and four female. Practically all had x-ray therapy only after measures ordinarily employed had proven unsuccessful. As a result of adding irradiation to the treatment, none required surgery or injection. The technic employed was: 140 K.V.P., 20-inch distance, Cu $\frac{1}{4}$ mm. plus Al 1 mm., from 40 to 50 milliamperes minutes, giving 150 r units per dose. The field was the cardiac area anteriorly and occasionally posteriorly. Treatments were given every two weeks until four treatments had been administered, further treatments being given at six- to eight-week intervals. Benefit was often not observed until the third or fourth treatment. Roentgentherapy in this series proved rather uniformly successful and worthwhile in the experience of the patients and in the estimation of the clinicians caring for these cases.

J. E. HABBE, M.D.

THE JOINTS

The Meniscus of the Knee Joint in Roentgenograms. Otto Dittmar. *Röntgenpraxis*, May, 1932, IV, 442-445.

That only a diseased, calcified meniscus may be demonstrated on roentgenograms is the opinion of most authors. Dittmar believes that it might be possible to show the meniscus and the medial, real joint-slit if one fixes the knee in abduction. He succeeded in a normal knee of a child and a pathologic knee of an adult (injury to the cartilage of the knee). No contrast material or air was used for this purpose. These findings prove that not every roentgenologic meniscus must be pathologic.

H. W. HEFKE, M.D.

Calcification of the Meniscus in the Roentgenogram (Primary Meniscopathy). A. Henrichsen. *Röntgenpraxis*, May, 1932, IV, 403-405.

Only 18 cases of primary non-traumatic calcification of the menisci have been reported, 14 of them by Mandl. This condition is often bilateral, a fact which accounts for the non-traumatic genesis. In the author's case the roentgenograms also showed characteristic lines of calcification in the region of the menisci of both knees. Degenerative processes (round-cell infiltration, degeneration of the cartilage, edema of the connective tissue, formation of small cysts, and circumscribed or diffuse calcium deposition) are evident on histologic examination. The author believes that arthritic processes, in his case, are the basis of the changes in the menisci.

H. W. HEFKE, M.D.

THE KIDNEYS

Horseshoe Kidney: A Report of Five Cases. Joseph A. Lazarus. *Jour. Urol.*, April, 1932, XXVII, 471-487.

The author draws the following conclusions:

- (1) Horseshoe kidney is not a rare anomaly, occurring in about 0.1 per cent of normal persons;
- (2) The above mentioned kidneys are relatively more prone to pathologic lesions than are normally formed kidneys;
- (3) There are no symptoms characteristic of horseshoe kidney. When symptoms occur, they are due to some associated pathologic lesion;
- (4) Most cases of horseshoe kidney have been diagnosed at the time of operation or at post-mortem examination;
- (5) A careful study of a good flat kidney roentgenogram will usually suffice to lead to the suspicion of this anomaly by showing the proximity of the renal silhouette to the vertebral column, by the obliteration of the psoas margins in part or in their entirety, and by the failure to visualize one or the other of the renal poles;
- (6) Pyelography clinches the diagnosis of horseshoe kidney by showing the bizarre pelves and calices usually pointing anteriorly and approximated to the midline and shortening of the ureters;
- (7) The best treatment for an extensive suppurative lesion, tumor, or tuberculosis involving one half of a horseshoe kidney is heminephrectomy. All other diseases involving horseshoe kidneys are treated in exactly the same manner as are similar diseases in normally formed kidneys;
- (8) The diagnosis of horseshoe kidney prior to operation will greatly facilitate operative procedures upon such kidneys.

DAVIS H. PARDOLL, M.D.

Calculus Disease Complicating Horseshoe Kidney. J. Sydney Ritter and Leo A. Shifrin. *Urol. and Cutan. Rev.*, May, 1932, XXXVI, 311-313.

The authors discuss the embryology, diagnosis, and treatment of horseshoe kidney associated with calculi and report a case of this rare condition.

Horseshoe kidney is a very early embryologic defect. As early as the 8 mm. embryo, either the upper or the lower pole of one kidney may fuse with the upper or lower pole of the kidney on the opposite side, or they may unite centrally. Fusion of the lower poles is the most common entity encountered, because these two poles are nearer to each other during the development of the kidneys. The amount of kidney parenchyma present in this bridge of union depends upon the time of fusion of the kidneys. Since the pelvis and ureters develop separately and earlier, they are not involved in this anomaly but cross the commissural kidney tissue anteriorly.

The x-ray has proved of considerable value in the diagnosis of renal calculus disease and horseshoe kidney. In addition to the shadows of the calculi on the roentgenogram, there is usually a suggestion of a connecting bridge between the kidneys. The authors are of the opinion that a definite diagnosis of horseshoe kidney can almost always be made by the use of intravenous urography. The importance of correct pre-operative diagnosis is emphasized.

Horseshoe kidney alone may cause no symptoms, but the associated calculi usually produce sufficient subjective symptoms to make the patient consult a urologist. Anterior pyelotomy, which does not require delivery of the kidney into the wound, is the operation of choice.

J. N. ANÉ, M.D.

Carbuncle of the Kidney (Metastatic Staphylococcus Abscess of the Kidney Cortex). Leo Brady. *Jour. Urol.*, March, 1932, XXVII, 295-316.

A case of renal carbuncle is reported, accompanied by a review of the literature on this subject.

The essentials of a diagnosis are a history of a preceding staphylococcal infection of the skin or of the respiratory tract. The urine is usually normal. A palpable mass may be felt under the costal margin on the affected side, particularly if accompanied by a perinephritic involvement.

The findings in the pyelogram are those usually found in a tumor of the kidney, namely, obliteration of one calyx, with elongation of another, due to

the pressure of the mass exerted on the pelvis. The differential phthalein test may be of value in showing diminished function on the affected side.

Perinephritic abscess and multiple septic embolic abscesses of the renal cortex are to be considered in the differential diagnosis.

The treatment varies according to the extent of the condition or the technic of the surgeon. Nephrectomy, resection, enucleation, and simple exposure, with drainage, are recommended.

The pyelo-ureterogram of the case reported and a bibliography accompany the article.

DAVIS H. PARDOLL, M.D.

RADIATION INJURIES

Extensive Roentgen Ulcer, in a Patient with Diabetes, Healed after Six Years' Duration. Gustav Singer. *Strahlentherapie*, May 11, 1932, XLIV, 147-160.

A woman, 46 years of age, was admitted to the author's clinic in March, 1931. She had had uterine hemorrhage, in 1925, and received at that time X-ray therapy over the posterior splenic region. A severe reaction followed which resulted in the development of an extensive roentgen ulcer. She had to remain in the hospital for three years, undergoing treatment for this ulcer, and was kept under observation and ambulatory treatment for the following two years. The patient, who also developed diabetes, suffered from such severe pain and insomnia that morphine had to be given. She succeeded in obtaining this drug and reached a daily dose of 0.5 gram.

When seen in March, 1931, there was a roentgen ulcer 18 cm. long, 12 cm. wide, and 3 cm. deep in the left lower back at the height of the eighth dorsal vertebra. The base of the ulcer was covered by granulations and thin pus. The Wassermann reaction was +4. Insulin did not have any effect on the healing of the ulcer, therefore, non-specific protein injections were given. At the same time withdrawal treatment for the morphine addiction was started. Under the protein treatment the ulcer began to heal and fill in very slowly, and a scar developed. Several photographs show the progress of the healing. It was interesting to note that the diabetes was also favorably influenced by the protein injections. A sequestrum of the ninth rib was removed in March, 1932, and the wound was healing well at the time the report was written.

ERNST A. POHLE, M.D., Ph.D.

